INTERNATIONAL
HYDROGRAPHIC
ORGANIZATION

INTERGOVERNMENTAL
OCEANOGRAPHIC
COMMISSION (of UNESCO)

G E B C O

GUIDELINES FOR THE GENERAL BATHYMETRIC CHART OF THE OCEANS

September 1991

Published by the
INTERNATIONAL HYDROGRAPHIC BUREAU

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GUIDELINES FOR THE

GENERAL BATHYMETRIC CHART OF THE OCEANS

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F O R E W O R D

The IHO/IOC publication B-7 (formerly BP-0007) "Guidelines for the General Bathymetric Chart of the Oceans" supersedes the IHO publication "Regulation for the General Bathymetric Chart of the Oceans - Standards for Processing of Data" the 1st Edition of which was issued in March 1970 after consultation with the IHO Volunteering Hydrographic Offices (VHOs) that had accepted responsibility for centralizing the oceanic soundings, the former "GEBCO Committee" and the "Institut Géographique National" of France.

Following the establishment of the Joint IHO-IOC Guiding Committee for the GEBCO, the setting up of a new organization responsible for the publication of the GEBCO, now at its 5th Edition, the increasing use of digital methods for storing bathymetric data, the introduction of multibeam sounding systems and the need to handle geophysical data collected concurrently with bathymetric data, the March 1970 GEBCO Regulations were no longer applicable or adequate. In addition, the use of the term "Guidelines" instead of "Regulations" in the title, was considered more appropriate by the GEBCO Officers during their 7th Meeting (Bremerhaven, Germany, 30 May - 1 June 1990).

The GEBCO Guidelines are subdivided into five parts, i.e.:

PART 1 - GEBCO ORGANIZATIONAL FRAMEWORK brings together the responsibilities and Terms of Reference of the various Committees and Bodies which are connected with the GEBCO project.

PART 2 - BATHYMETRIC DATA MANAGEMENT describes the role of IHO Member States' Hydrographic Offices in the management of the data associated with the 1:1M and 1:250 000 bathymetric plotting sheets, and lays down the specifications regarding the oceanic digital data base and oceanic plotting sheets. This Part is itself subdivided into two sections :

Section A	-	Analogue Data
Section B	-	Digital Data

PART 3 - DIGITAL BATHYMETRIC DATA (SINGLE-BEAM ECHO SOUNDERS) gives guidance on the processing and storing of digital bathymetric data collected by single-beam echo sounders.

PART 4 - DIGITAL BATHYMETRIC DATA (MULTIBEAM ECHO SOUNDERS) gives guidance on the processing and storing of digital bathymetric data collected by multibeam sounding systems.

PART 5 - UNDERWAY GEOPHYSICS DATA gives guidelines for storing underway magnetic and gravity digital data concurrently with bathymetric data.

In addition, three Annexes are attached to the Publication, i.e.:

ANNEX 1	-	Assembly Diagram for GEBCO sheets (5th Edition).
ANNEX 2	-	Specifications for International Bathymetric Charts (IBC) produced under IOC's regional ocean mapping projects.
ANNEX 3	-	Acronyms and Abbreviations.

LIST OF EFFECTIVE PAGES

Numbering	Pages in force	Numbering	Pages in force
i (reverse blank)	Original	2-13	06/93
iii (reverse blank)	06/93	2-14	06/93
v	03/92	2-15 (reverse blank)	06/93
vi	Original	2-17 (reverse blank)	06/93
vii (reverse blank)	06/93		
PART 1		**PART 3**	
		3-i (reverse blank)	03/92
1-i	06/93	3-1	06/93
1-ii	Original	3-2	03/92
1-1	03/92	3-3	03/92
1-2	Original	3-4	03/92
1-3	Original	3-5	03/92
1-4	Original	3-6	03/92
1-5	06/93	3-7 (reverse blank)	03/92
1-6	09/93	3-9 (reverse blank)	03/92
1-7	Original	3-11 (reverse blank)	03/92
1-8	06/93	3-13	06/93
1-9	06/93	3-14	06/93
1-10	06/93		
1-11	Original	**PART 5**	
1-12	Original		
1-13	Original	5-i (reverse blank)	03/92
1-14	Original	5-1	03/92
1-15	Original	5-2	03/92
1-16	Original	5-3	03/92
1-17	Original	5-4	03/92
1-18	Original	5-5 (reverse blank)	03/92
1-19	Original	5-7 (reverse blank)	03/92
1-20	Original		
1-21	Original	**ANNEXES**	
1-22	Original		
1-23	Original	A-1 (reverse blank)	Original
1-24	Original	A-3	Original
		A-4	Original
PART 2		A-5	Original
		A-6	Original
2-i (reverse blank)	06/93	A-7 (reverse blank)	Original
2-1	Original	A-9	Original
2-2	Original	A-10	Original
2-3	Original	A-11	06/93
2-4	06/93	A-12	06/93
2-5	Original		
2-6	Original		
2-7	Original		
2-8	Original		
2-9	06/93		
2-10	06/93		
2-11	06/93		
2-12	06/93		

PART 1

GEBCO ORGANIZATIONAL FRAMEWORK

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CONTENTS

1.1 - THE GENERAL BATHYMETRIC CHART OF THE OCEANS (GEBCO)

The preparation of the first world series of oceanic bathymetric charts was started in 1903, and was published one year later as the GEBCO, under the auspices of Prince Albert Ier of Monaco.

As additional data became available over the years, new editions were compiled, first by the Prince's scientific committee and later, after the Prince's death, by the International Hydrographic Bureau. The last sheet of the 4th Edition, which was printed by the Institut Géographique National (IGN) of France, was published in 1973.

With the increasing knowledge of the morphology and of the geological processes on the ocean bed in the 1950s and 1960s, a scientific input into the preparation of the contours was introduced into GEBCO by linking the Intergovernmental Oceanographic Commission (IOC) with the IHO as joint sponsors of the project.

Under the new Joint IOC/IHO Guiding Committee for the GEBCO, a 5th Edition was prepared and completed in 1982 (see the Assembly Diagram of the 5th Edition in Annex 1).

This edition differed in many ways from its predecessors. There were new sheet boundaries, new specifications, sounding control was shown by track lines and dots, and an extensive scientific review process was carried out prior to publication.

The contours of the 5th Edition have ben digitized, together with the tracks, sounding control and the names, to form the basis for the "GEBCO Digital Atlas" (GDA) which will initially be available on magnetic tape, and later on CD-ROM.

The database of the GDA will be updated as new contour data are acquired and blocks of older data will be replaced. Users will be able to extract from the database the areas they need on any suitable scale.

At an appropriate time it is planned to produce a 6th Edition of printed sheets from the GDA database.

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1.2 - THE ORGANIZATION AND COMPONENTS OF THE GEBCO SYSTEM

1.2.1 Oceanic soundings are acquired by hydrographic and oceanographic ships during surveys and on passage between survey areas and ports. In addition many warships, fisheries ships and others collect oceanic soundings. These are submitted either as soundings plotted on sheets, or increasingly as digital tapes or discs.

1.2.2 The Joint IOC-IHO Guiding Committee for GEBCO has overall responsibility for guiding the GEBCO project and determining the policy for the preparation and dissemination of the world series of contoured charts of the ocean floor and of the "GEBCO Digital Atlas" (GDA), acting on behalf of the two parent organizations.

1.2.3 The soundings are collected together by the IHO Volunteering Hydrographic Offices (VHOs) in internationally agreed areas, or by the IHO Data Centre for Digital Bathymetry (DCDB) at Boulder, Colorado, USA.

1.2.4 Contours are prepared from all available data sources by geoscientists who have expertise in the area. They may be from Universities, Government Institutions, Hydrographic Departments or Industry. The Guiding Committee is responsible for appointing reviewers to assess when sufficient new data are available to justify recontouring and updating of the database, and for ensuring that this is done.

1.2.5 The GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features recommends to the Guiding Committee names to be included in the charts and the GDA. These are also published in the IHO-IOC Gazetteer of Geographical Names of Undersea Features shown (or which might be added) on the GEBCO and on the IHO small-scale International Chart Series (1:2,250,000 and smaller) - Publication B-8 (formerly BP-0008).

1.2.6 The GEBCO Sub-Committee on Digital Bathymetry advises the Guiding Committee on procedures to achieve a fully digital version of GEBCO charts and to prepare the "GEBCO Digital Atlas" (GDA).

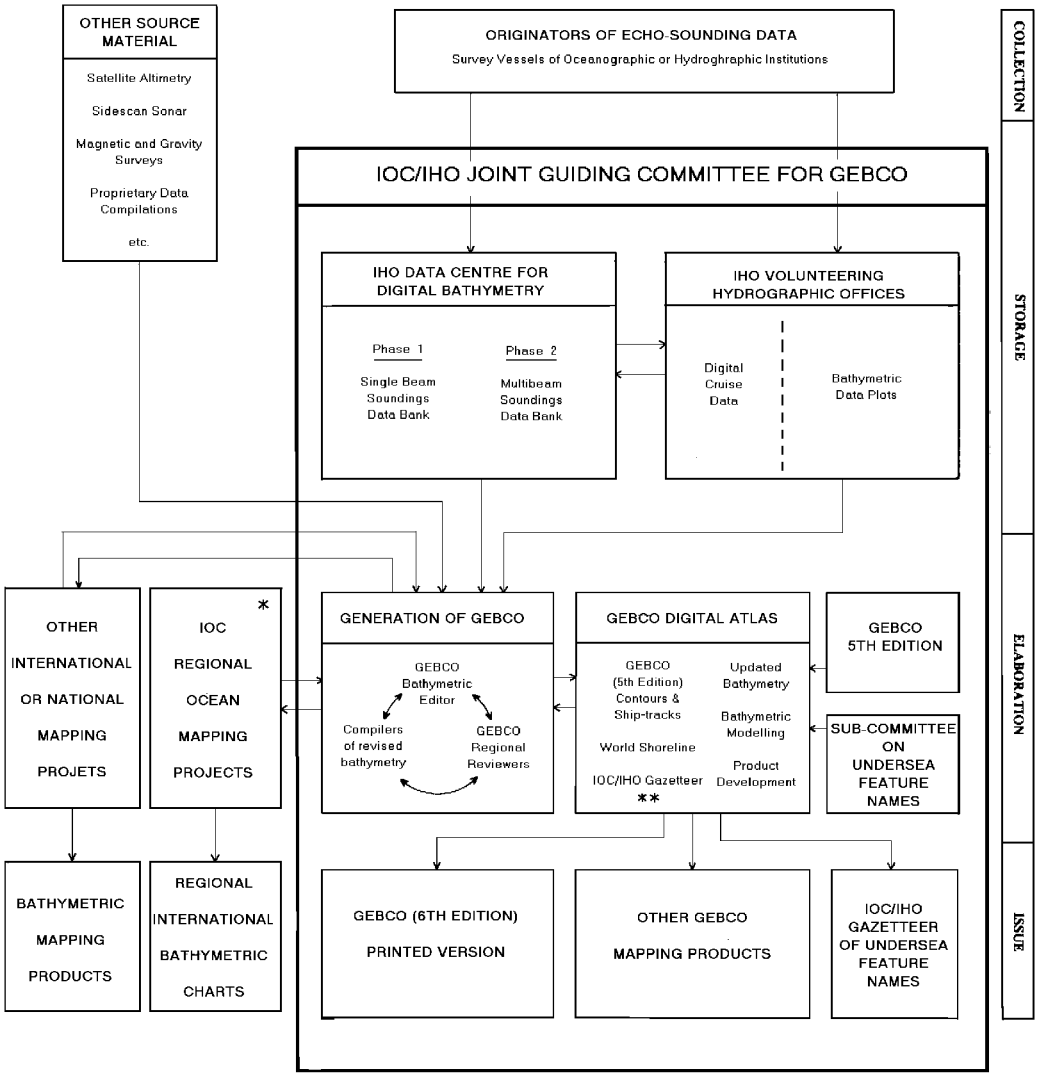
1.2.7 The GEBCO project is one of a number of bathymetric and geophysical mapping projects sponsored by the IOC. Others include atlases, of the Indian and Atlantic Oceans, already published, and of the Pacific Ocean, in preparation. IOC is also responsible for a number of Regional Mapping projects (see specifications in Annex C), with which the IHO is closely involved. These mapping projects are co-ordinated by the IOC Consultative Group on Ocean Mapping (CGOM). (See Section 1.9).

1.2.8 The success of the GEBCO project depends on the voluntary help of many dedicated scientists and hydrographers working to a common goal, and operating in a flexible way. Several Governments have donated substantial resources towards achieving this goal.

1.2.9 The following sections (1.3 to 1.8) reproduce the Terms of Reference and documentation supporting the various component bodies which make up the GEBCO project as a whole, together with references to authoritative sources.

1.2.10 A Structural Diagram illustrating the relationships of these components is given on page 1-3.

GEBCO STRUCTURAL DIAGRAM



* Specifications of International Bathymetric Charts produced under Regional Ocean Mapping Projects in Annex 2

** Data Base held at the IHB

1.3 - GEBCO GUIDING COMMITTEE

1.3.1 Form of Understanding between the Co-sponsoring Bodies on Membership of the Joint IOC-IHO Guiding Committee for the GEBCO.

1.3.1.1 At the formation of the Joint IOC-IHO Guiding Committee for GEBCO in November 1973, it was decided that members would be nominated by the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) Secretariats, in consultation with the Scientific Committee on Oceanic Research (SCOR), the International Association for the Physical Sciences of the Ocean (IAPSO) and the Commission for Marine Geology (CMG); five members being selected by IHO, two by IOC and one each by SCOR, IAPSO and CMG.

1.3.1.2 Based on this decision, an understanding has been reached between the IHB and the IOC Secretariat that Membership of the Guiding Committee would be covered by the following guidelines :

(1) The Guiding Committee will consist of 10 members, five of whom will be nominated by IHO and five by IOC. Of the IOC members, two will be selected by IOC, one by SCOR, one by IAPSO and one by CMG.

(2) In close consultation, the Co-sponsoring Bodies will ensure that members of the Guiding Committee will be appointed on a wide geographical basis and that no more than one member will be nominated from any one country.

(3) Members of the Guiding Committee are experts acting in their personal capacity and shall not represent their government.*

1.3.1.3 Invitations to sessions of the Guiding Committee will be sent to all GEBCO Sheet Co-ordinators as well as members of the Committee.

1.3.1.4 Meetings are open to any interested scientists and hydrographers who may wish to attend as observers.

* So far as IOC is concerned, the Guiding Committee is classed as a Joint Group of Experts under the IOC guidelines for subsidiary bodies.

References:

a) Document IOC/EC-IV/3, item 4.3.1. Report of the 4th Session of the IOC Executive Council, Paris, France, 17-22 June 1974.

b) Document IOC-IHO/GEBCO-V/3, paragraph 10. Summary Report of the 5th Meeting of the GEBCO Guiding Committee, Ottawa, Canada, 24-26 April 1978.

1.3.2 Joint IOC-IHO Guiding Committee for the GEBCO - Terms of Reference

The Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of Oceans (GEBCO) shall:

(1) Guide the GEBCO project and make recommendations to the two parent organizations on the policy to be followed for the preparation and dissemination of that world series of contoured charts of the ocean floor and of the "GEBCO Digital Atlas".

(2) Identify the needs of the various users of the bathymetry of the world's oceans, study the ways and means whereby these needs can be met, and implement actions found feasible which meet these needs.

(3) Advise the International Hydrographic Organization (in its capacity as the World Data Centre for Bathymetry) on matters connected with the collection and exchange of bathymetric data, including the development of automatic data assimilation, archival, retrieval and distribution methods, soliciting the advice and assistance of the IOC Committee on International Oceanographic Data and Information Exchange (IODE), and others as necessary.

(4) Stimulate the flow of data relevant to GEBCO by actively identifying sources of new data and encouraging release of data to appropriate data banks, with the object of ensuring that maximum available data are provided to the World Data Centre for Bathymetry and its IHO Data Centre for Digital bathymetry.

(5) Supervise the means of maintaining, further developing and routinely updating the "GEBCO Digital Atlas" (GDA) activities:

  (i) organizing procedures for new compilations of bathymetry;

  (ii) advising on standards and methodology;

  (iii) generating and developing a supplementary file containing shiptracks, for the purpose of providing graphic presentation for quality assurance related to interpreted bathymetric information;

  (iv) integrating in an appropriate way the geographical names of undersea features; and

  (v) considering the best medium and software for the effective use of the GDA by all users.

(6) Explore the potential, for the better interpretation of oceanic bathymetry, of techniques such as acoustic imagery and satellite observations.

(7) Taking into account the new technologies and data available, draft specifications and a timetable for the production of a 6th Edition of the traditional printed GEBCO chart series.

(8) Investigate and develop new extra-budgetary logistic and financial arrangements necessary for the production of a 6th Edition of GEBCO.

(9) Prepare and maintain, in association with national and international bodies, an authoritative Gazetteer on Geographical Names of Undersea Features.

(10) Recommend and develop measures for optimum publicity, distribution and sales of copies of the "GEBCO Digital Atlas" and printed charts produced under the aegis of the Guiding Committee.

(11) Maintain, as necessary, advisory Sub-Committees on:

(i) Undersea Feature Names,

and (ii) Digital Bathymetry,

and create others as required from time to time.

(12) Advise regional bodies affiliated to IOC and/or IHO of the specifications for, and collaborate in the preparation of, bathymetric charts at scales suitable for regional projects, to help ensure their compatibility with, and later inclusion in, the GDA.

(13) Provide advice on ocean mapping, as requested by intergovernmental and non-governmental organizations.

References:

a) *Document IOC/XVII/3. Report of the 17th Session of the IOC Assembly, Paris, France, 25 February - 11 March 1993.*

b) *IHB Circular Letter 42/1993 of 15 September 1993.*

1.3.3 Role of Scientific Advisers to the GEBCO

A number of experts who have particular interest in the GEBCO, the 6th Edition of the traditional printed paper chart series, and the GEBCO Digital Atlas, have been designated "Scientific Advisers to the GEBCO". They provide advice, within their particular fields of expertise, to the Guiding Committee for GEBCO on request and in return they are kept fully informed of developments and are invited to attend, and contribute to, meetings of the Guiding Committee and where appropriate the GEBCO Sub-Committees.

1.4 - GEBCO SUB-COMMITTEES

1.4.1 GEBCO Sub-Committee on Undersea Feature Names (SCUFN) - Terms of Reference.

(1) The Sub-Committee on Undersea Feature Names reports to the Guiding Committee as its designated authority for all matters concerning undersea feature names.

(2) It is the function of the Sub-Committee to select those names appropriate for use on GEBCO graphical and digital products, on the IHO small-scale INTernational chart series, and on the IOC regional international Bathymetric Chart series.

(3) The Sub-Committee shall:

(i) select undersea feature names on the basis of:

a) undersea feature names provided by national and international organizations concerned with nomenclature;

b) names submitted to the Sub-Committee by individuals, agencies and organizations involved in marine research, hydrography, etc.;

c) names appearing in scientific journals or on appropriate charts and maps, with valid supporting evidence.

Such names will be reviewed before they are inputted into the Gazetteer.

(ii) define when appropriate the extent of named features;

(iii) provide advice to individuals and appropriate authorities on the selection of undersea feature names in international waters and, on request, in waters under national jurisdiction;

(iv) encourage the establishment of national boards of geographical names and undersea features, and when such a board does not exist for a given coastal state, co-operate in the naming of seafloor features related to those national waters;

(v) prepare and maintain international gazetteers and supplements of undersea feature names;

(vi) encourage the use of undersea feature names shown on GEBCO products, on other maps, charts, scientific publications, and documents by promulgating them widely;

(vii) prepare and maintain internationally agreed guidelines for the standardization of undersea feature names and encourage their use;

(viii) review and address the need for revised or additional terms and definitions for submarine topographic features.

(ix) maintain close liaison with the UN Group of Experts on Geographical Names and international or national authorities concerned with the naming of undersea features.

Reference:

Document IOC-IHO/GEBCO - XIV/3. Summary Report of the 14th Session of the Joint IOC-IHO Guiding Committee for the GEBCO, La Jolla, USA, 4-6 May 1993.

1.4.2 GEBCO Sub-Committee on Digital Bathymetry (SCDB) - Terms of Reference

The Sub-Committee on Digital Bathymetry shall :

(1) Maintain a watching brief on developments in deep sea bathymetric mapping and related activities, and on the evolving technologies used to support such work.

(2) Keep under review, and provide advice on, standards and procedures for ensuring the continued and effective management, availability and depiction of digital bathymetric data.

(3) Maintain, routinely update and further improve the GEBCO Digital Atlas (GDA) by:

(i) developing procedures for incorporating new compilations of bathymetry;

(ii) advising on standards and methodology;

(iii) generating and developing a supplementary file containing shiptracks, for the purpose of providing graphic presentation for quality assurance related to interpreted bathymetric information;

(iv) integrating in an appropriate way the geographical names of undersea features; and

(v) investigating the best medium and software for the effective use of the GDA by all users.

(4) Explore the potential, for the better interpretation of oceanic bathymetry, of techniques such as acoustic imagery and satellite observations which do not produce precise sounding data.

(5) Investigate and recommend ways and means by which digital methods may be used to expedite production of the GEBCO (6th Edition).

(6) Advise through the Guiding Committee, the International Hydrographic Organization (In its capacity as the World Data Centre for Bathymetry) on matters connected with the collection and exchange of bathymetric data, including the development of automatic assimilation, archival, retrieval and distribution methods, soliciting the advice and assistance of the IOC Committee on International Oceanographic Data and Information Exchange (IODE), and others as necessary.

(7) Stimulate the flow of data relevant to GEBCO by actively identifying sources of new data and encouraging release of data to appropriate data banks, with the object of ensuring that maximum available data are provided to the World Data Centre for Bathymetry and its IHO Data Centre for Digital Bathymetry.

(8) Interact with the IHO Committee on Exchange of Digital Data (CEDD) and with other relevant committees and working groups, to bring about, to the extent possible, uniformity and compatibility with IODE developments and also with IHO Classification Criteria for Deep Sea Soundings (IHO Special Publication No. 44, Chapter 2).

Reference:

Document IOC-IHO/GEBCO - XIV/3. Summary Report of the 14th Session of the Joint IOC-IHO Guiding Committee for the GEBCO, La Jolla, USA, 4-6 May 1993.

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1.5 - GEBCO MAPPING

1.5.1 GEBCO Bathymetric Editor - Terms of Reference

The GEBCO Bathymetric Editor will be responsible for maintaining a supervisory role over the flow of data relevant to GEBCO by:

(1) searching out new data sources and ensuring that, within the limits of propriety for publication by originating investigators, all available data are deposited in data banks in timely fashion;

(2) keeping himself informed of ongoing and planned field bathymetric programmes throughout the world;

(3) be acquainted with and maintain contact with those academic and agency geoscientists and hydrographic services demonstrably interested in and actively researching the geomorphology of the world's oceans, as well as the technical groups engaged in the forefront of processing and manipulation of such data;

(4) to receive and assess recommendations from the network of reviewers for the upgrading of the GEBCO Digital Atlas (GDA) and to negociate for the acquisition of the data and its transmission to the GDA Manager;

(5) to identify possible compilers of revised blocks of contours, make recommendations to the Guiding Committee and subsequently to liaise with the compilers;

(6) to develop close links with the IHO as the World Data Centre for Bathymetry, and the IHO Data Centre for Digital bathymetry at Boulder, USA;

(7) to liaise with national and international organizations involved in ocean mapping (e.g. IOC, IHO, ICA and CGMW);

(8) to provide active support to the GEBCO Guiding Committee;

(9) to work closely with the GDA Manager and to supply all necessary material to the appropriate establishment which has undertaken to produce and print the GEBCO (6th Edition) printed chart series.

Reference:

Document IOC-IHO/GEBCO Officers - VII/3, paragraphs 49 and 50. Summary Report of the 7th Meeting of the GEBCO Officers, Bremerhaven, FRG, 31 May - 1 June 1990.

1.5.2 Role of GEBCO Reviewers

Following the publication of the GEBCO (5th Edition) in traditional printed chart form, the bathymetric contours therefrom, together with certain ancillary data (ship tracks, geographical names of undersea features, etc.) were digitized and made available to users on magnetic tape. By creating a structure making this database subject to continual updating and improvement by splicing in new blocks of data as and when they become available, a "GEBCO Digital Atlas" (GDA) is being maintained which, besides being of considerable value in its own right, can also be used at any time for the preparation of the 6th and subsequent editions of the traditional GEBCO chart series.

An essential part of this structure is to have a Network of Reviewers covering all oceanic regions whose task it will be to work with the digital plots and their track control, and to keep the Joint IOC-IHO Guiding Committee for the GEBCO fully informed of the availability of new data and where sufficient exists to justify a block revision to any part of the database.

The role of the GEBCO Reviewers will be as follows:

1.5.2.1 Each GEBCO Reviewer is required to:

(1) Maintain a continuing review of all new bathymetric data that has become available within his area of responsibility since compilation of the relevant GEBCO (5th Edition) sheets;

(2) Advise the GEBCO Guiding Committee when sufficient new data have been collected to justify a block revision to any significant part of the database, within his area of responsibility.

1.5.2.2 To achieve these aims, Reviewers should:

(1) actively search for new data sources and establish a continuing relationship with the International Hydrographic Organization (IHO) as the World Data Centre for Bathymetry and/or direct with appropriate IHO Volunteering Hydrographic Offices (VHOs), and with the IHO Data Centre for Digital Bathymetry;

(2) bring to the attention of the IHO World Data Centre for Bathymetry or the IHO Data Centre for Digital Bathymetry (as appropriate) the existence of any datasets which have not already reached them;

(3) ensure, when making any recommendations to the Guiding Committee, that they have an adequate inventory of new data to present in support of their proposals;

(4) be prepared to attend and present their proposals in person to the Guiding Committee;

(5) maintain close liaison with IOC's regional Ocean Mapping bodies (and their Editorial Boards), and with IHO's Regional Hydrographic Commissions, within their areas of responsibility;

1.5.2.3 In support of the above aims:

(1) Volunteering Hydrographic Offices (VHOs) will be asked to provide Reviewers with free updates of 1:1 million and 1:250,000 Plotting Sheets, on request;

(2) The IHO Data Centre for Digital Bathymetry will provide on request information on all datasets in their possession (with necessary documentation) for Reviewers' areas of responsibility.

Note : All correspondence with the Centre should clearly identify the writer as a GEBCO Reviewer.

Reference:

Document IOC-IHO/GEBCO - XII/3. Summary Report of the 12th Session of the Joint IOC-IHO Guiding Committee for the GEBCO, Boulder, USA, 16-17 May 1989.

1.5.3 Compilers of Revised Bathymetry

Most of the revised bathymetry that will be incorporated into the "GEBCO Digital Atlas" will come from new compilations which have been prepared for other purposes outside the GEBCO structure, i.e. for the "IOC Regional Ocean Mapping Projects" and for "Other international and national mapping projects" (see the GEBCO Structural Diagram on page 1-3).

The compilers of these products will be invited, where practicable, to adhere to the GEBCO Specifications, e.g. soundings in corrected metres, standard contour value and intervals, etc., in consultation with the GEBCO Bathymetric Editor. In the case of the IOC Regional Ocean Mapping Projects, such consultation will take place under the guidance and authority of IOC's Consultative Group on Ocean Mapping (see the Terms of Reference on page 1-20). It is to be expected that some (if not most) of the "Other international and national mapping projects" will not adhere to the GEBCO Specifications. In such cases it will be the responsibility of the GEBCO Bathymetric Editor to carry out the necessary conversion himself or to find compilers to undertake this task.

In addition to, and separate from the above, each Reviewer is required by his Terms of Reference to report that he has identified sufficient new data in a part of his area of responsibility to justify a block revision to that part of the database. On these occasions, it will be the responsibility of the GEBCO Bathymetric Editor, acting on behalf of the GEBCO Guiding Committee, to find and work with a suitably qualified geoscientist on a new compilation which will meet GEBCO standards, and which when complete, can be incorporated into the database as a block correction.

1.6 - GEBCO DIGITAL ATLAS (GDA)

1.6.1 GEBCO Digital Atlas Manager - Terms of Reference

The GEBCO Digital Atlas (GDA) Manager will be responsible for :

(1) receipt of digital tapes from IGN/BGI, HDNO, JODC, IHB and elsewhere, of digitized contours, ships tracks and geographical names from the 5th edition GEBCO;

(2) receipt of tapes of digitized data from other sources (e.g. IOC regional mapping projects);

(3) examination and editing of all tapes received for errors, ambiguities and inconsistencies;

(4) merging inputs into a unified database in a standard format suitable for subsequent distribution and sales;

(5) maintenance and periodical updating of the GDA by the integration of new blocks of data when supplied through the GEBCO Bathymetric Editor, and digitizing where necessary;

(6) substitution of the existing coastline in the GDA by the new USA-DMA coastline (World Vector Shoreline) making necessary adjustements to nearshore bathymetric contours;

(7) researching and implementing new data files such as gridded databases (DTMs);

(8) researching and implementing new output presentations from the GDA to meet the needs of users and to demonstrate its flexibility;

(9) advising on programmes of output presentations that could be available to users;

(10) prepare for conversion of GDA to (e.g.) CD-ROM.

Reference:

Document IOC-IHO/GEBCO Officers - VII/3. Summary Report of the 7th Meeting of the GEBCO Officers, Bremerhaven, FRG, 30 May - 1 June 1990.

1.7 - INTERNATIONAL HYDROGRAPHIC ORGANIZATION (IHO)

1.7.1 Role of the International Hydrographic Bureau (IHB) in connection with GEBCO

(1) To coordinate the work on the GEBCO carried out by the Volunteering Hydrographic Offices (VHOs);

(2) To retain a complete archives of copies of non-distributables plotting sheets and annexed documents received from the VHOs whenever any such plotting sheet is published or brought up to date and, upon receipt of copies of these documents, to invite the attention of the Hydrographic Office responsible to any points that may be relevant concerning application of the "Guidelines for Bathymetric Plotting Sheets". The management of digital bathymetric data is carried out on behalf of the IHO, by the US National Geophysical Data Center (NGDC) of Boulder (Colorado) (see 1.7.2). It is possible that, in the future, additional regional data centres may be established.

(3) To notify the VHOs concerned of all bathymetric data it receives and to inform such offices of the existence of data that have been brought to its attention.

(4) To remind, where necessary, the Hydrographic Offices of all its Member States that they should do their utmost to encourage their various national organizations to send to the VHOs concerned, either directly through them, or through the IHB if more appropriate, all the bathymetric data in their possession.

(5) To remain in contact with international organizations - such as the IOC and the "World Data Centres" - so that these bodies regularly supply the VHOs concerned with all the data available to them.

(6) To ensure that these Guidelines are applied by all those participating in the work of centralizing all oceanic soundings and to propose, where required, any amendments to the Guidelines.

(7) To publish a "Catalogue of IHO Bathymetric Plotting Sheets" (formerly BP-0002) and its annex (formerly BP-0003), indicating the zones of responsibility of the VHOs, the identification numbers of the plotting sheets corresponding to each such zone, and, insofar as the relevant information has been received from the Hydrographic Offices responsible, the dates of publication or latest bringing up to date of plotting sheets, and the addresses of the VHOs so that users may obtain from them upon request, made either directly or through the IHB, copies of any plotting sheets they may require and information of the price of these. The catalogue of IHO BPS is to be inserted in publication B-7 along with its annex, available in digital form only on disc, and which includes the address of the IHO Data Center for Digital Bathymetry (DCDB) from which digital bathymetric data in a given area can be obtained by the users.

(8) To issue, annually, on the basis of information supplied by the IHO Member States, a summary list of "Information concerning recent bathymetric data" B-4 (formerly BP-0004), collected throughout the world.

(9) To supervise, jointly with the IOC, the work of the IOC-IHO Guiding Committee for the GEBCO and its Sub-committees.

(10) To request, whenever a new edition of the GEBCO is due to be published, that the VHOs concerned forward to the IHB, for each plotting sheet for which they are responsible, two copies of the sheet of soundings and one copy of the source overlay.

(11) To bring to the attention of all those participating in work on the GEBCO any comments it may wish to make or it may receive concerning the GEBCO documents.

1.7.2 Services to be provided by the IHO Data Centre for Digital Bathymetry (DCDB)

Services to be provided by the US National Geophysical Data Center (NGDC) on behalf of the IHO will include but not be limited to:

(1) Operation of the data center with a focus of activity on oceanic regions with depths greater than 100 meters.

(2) Provision free of charge, to the IHO for use by its Member States, of the data needed for their national or international projects. The IHO Member States will submit their requests for data through the International Hydrographic Bureau (IHB). IHO Member States' Hydrographic Offices (HOs) will provide the center with the digital bathymetric data collected by their nation's institutions in oceanic regions.

(3) Maintenance of a quality control facility whereby data provided to the center are at least subjected to simple checks for violation of physical principles (instantaneous changes in position, impossibly high ship speeds, etc.) and completeness of labeling, referring detected obvious errors back to suppliers of data for possible corrections. Member States' Hydrographic Offices may be requested to assist in resolving matters of quality control concerning data originated by their nation's organizations.

(4) Maintenance of inventories in digital form of all digital bathymetric data including digital contour data and the production of an annually updated catalog of recently acquired bathymetric data. The center will provide this catalog to the IHB in a form analogous to the present IHO publication B-4 (formerly BP-0004).

(5) Maintenance of trackline catalogs of newly collected data to be provided upon the request of an IHO Volunteering Hydrographic Office (VHO) for its area of GEBCO responsibility.

(6) Collaboration with various international organizations in the development of exchange formats and standards to expedite bathymetric data exchange, including digital bathymetric contours.

The operational procedures, systems and formats supporting the Banking of Bathymetric data at the IHO DCDB are given in Annex A to this Part.

References:

a) Document IOC-IHO/GEBCO SCDB VII/3, paragraph 97. Summary Report of the 7th Meeting of the GEBCO Sub-Committee on Digital Bathymetry, Bremerhaven, FRG, 28 - 30 May 1990.

b) IHB Circular Letter 23/1990 of 25 June 1990.

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1.8 - INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC)

1.8.1 Role of the Intergovernmental Oceanographic Commission (IOC) in connection with GEBCO

(1) To provide advice and expertise, in consultation with SCOR, IAPSO and CMG, on the scientific input needed for the GEBCO so as to ensure that it remains a respected product of high quality;

(2) To ensure that the "GEBCO Digital Atlas" is developed as an important, highly respected operational database which is kept continually updated from all available new data as and when they become available;

(3) To provide guidance to the GEBCO Bathymetric Editor and the GEBCO Digital Atlas Manager on the requirements of the Commission in relation to Ocean Mapping;

(4) To develop, recommend and co-ordinate large-scale international regional ocean mapping projects which call for concerted action by the Member States, to ensure that the compilations thereof are digitized and incorporated into the "GEBCO Digital Atlas";

(5) To make recommendations to strengthen education and training in ocean mapping, and promote relevant projects in these fields as components of each of the IOC's regional ocean mapping projects;

(6) To supervise, jointly with the IHB, the work of the IOC-IHO Guiding Committee for the GEBCO and its Sub-committees;

(7) To publish the Summary reports of the sessions of the IOC-IHO Joint Guiding Committee and its Sub-committees (in English only);

(8) To work closely with the IHB in developing all the above activities.

1.9 - IOC CONSULTATIVE GROUP ON OCEAN MAPPING (CGOM) - TERMS OF REFERENCE

1.1.1 The IOC Consultative Group on Ocean Mapping shall:

(1) keep under continuous review all ocean mapping activities of the Commission, reporting biennially to the Assembly on progress made with each ocean mapping project sponsored (or co-sponsored) by the Commission;

(2) facilitate the exchange of expertise and experience between the groups supervising each such project;

(3) provide a technical link between the groups supervising each such project, so as to ensure that a standard form of presentation is used for all ocean mapping products published by, or on behalf of, the Commission; and

(4) encourage subsidiary regional bodies of the Commission to identify their requirements for bathymetric chart series and overlay (overprint) series showing other scientific parameters, including marine resources.

1.1.2 Composition

The IOC Consultative Group on Ocean Mapping will consist of the Chairmen (or their representatives) of all groups responsible for supervising ocean mapping projects sponsored (or co-sponsored) by the Commission.

1.1.3 Officers

The Group will elect its own Chairman and Vice Chairman.

Reference:

Annex to Resolution EC-XVII,3, 17th Session of the IOC Executive Council, Paris, France, 31 January - 9 February 1984.

ANNEX A

Operational Procedure, Systems and Formats supporting the Banking of Bathymetric Data at the IHO Data Centre for Digital Bathymetry (DCDB)

The IHO DCDB operates on the basis that the prime responsibility for quality control of the data rests with the collector or custodian of the raw data. DCDB receives data from IHO Member States' Hydrographic Offices or other national Institutions or Agencies in oceanic regions on 9-track magnetic tape, by direct computer - to - computer transfer over the networks, on floppy diskette, or on specially agreed-upon transfer media. Contributors are responsible for providing digital cruise data and headers (which list general information about the cruise and data acquired during the cruise) preferably in MGD77 format. The MGD77 format is described in a separate document available from DCDB. Data provided in other formats are accepted when accompanied with concise documentation. If data are provided to DCDB in an alternate format, written headers on MGD77 coding forms are accepted.

As soon as the data package arrives, DCDB reviews the accompanying written enclosures, checks the physical condition of the data storage media and assigns the data a project number used as a permanent identifier. Documentation which should be provided as enclosures with the data by each contributor is listed in Appendix 1. If data are not provided in MGD77 format, a concise description of the format used and completed MGD77 header coding forms should be included. DCDB provides enclosure forms and header coding forms to contributors on request. If the data and headers are in MGD77 format, or if the data are in a well documented alternate format with completed MGD77 header coding forms, data processing begins. Acknowledgement via mail or electronic mail is sent to the contributor within one week of receipt of the data. If necessary the acknowledgement includes a request for any information needed by DCDB to begin processing.

Within 3 weeks of the arrival of the data to DCDB they are copied for archival protection reasons and are scanned electronically using a digital scanning routine to determine whether the format matches that described in the written documentation. A manual check of the printout of the scanning routine is completed to determine if the data are entered in the proper record fields. After this scanning review is completed, a follow-up letter or electronic mail notice is sent to the contributor explaining the results and describing the expected date of completion of assimilation. This notice will also include a request for further documentation on any received format not familiar to DCDB staff.

The first step of assimilation occurs when the data are electronically transferred to a personal computer (DCDB now uses a 386 PC) to begin error checking. Software known as "QC77" is employed to routinely check several parameters. Latitude and longitude are checked to determine whether they fall within the normal ranges of 90° to -90° and 180° and -180° respectively. Each depth value, 2-way travel time, magnetic value, and gravity value is checked against physically possible values. Any value not physically possible (see Appendix 2) is flagged by the QC77 software. Navigation is also checked by comparing the time and navigation points for accelerations and/or course changes physically possible on an oceanic vessel. If there are errors discovered in the navigation check, plots of the navigation are reviewed. If there is a discrepancy, a staff person further reviews the situation and communicates with the contributor as necessary.

There are two checks done by DCDB staff at this point in the assimilation process. First the header record is reviewed for possible data entry errors. Second, randomly selected depths of the survey are compared to GEBCO chart depths as a check for two possible errors -- mismatched units of depth such as fathoms instead of meters or the misplacement of a decimal point in the depth record.

The staff at DCDB reviews any errors discovered and flagged by the QC77 software or during the two checks discussed above. If there are relatively few errors, the processing continues. But if there are a significant number of flagged errors, the contributor is notified and asked to correct and resubmit the data or provide enough information so the errors can be corrected by DCDB staff.

Next, software known as "77HI" is used to create an inventory file, which is a compacted version of each cruise. Normally the inventory file includes just enough data to define the trackline of the original cruise, usually about 2 percent of the total. The inventory file includes a list of the total number of data records for each parameter in the data set and a complete header for each cruise. The trackline of the inventory is displayed on a computer screen, where it is reviewed for obvious errors such as ship travel across a land mass, gaps in the cruise track or unusual navigational deviations. Quality Control processing is now complete.

The final assimilation steps are data management and archival functions. All assimilated cruises are added to the master inventory which is available for IHO Member States' hydrographic offices and other appropriate Agencies as described in documentation establishing the IHO DCDB. A copy of the master data file for each cruise is archived on-site and another off-site for added security. The inventory file, which is used by DCDB as part of the data request system, is also duplicated and stored in two locations. After the data are archived, the results of the DCDB QC77 checks are offered to the contributor of the data along with a copy of the assimilated data set.

Appendix 1 to Annex A

Documentation to be Provided with Data

ITEM	EXAMPLES
Contributor	Royal Australian Navy
Project Name	1986 Offshore Cruises
Contact	John Smith
Address	self explanatory
Telephone number	self explanatory
Facsimile number	self explanatory
Electronic mail address	(if applicable)
Digital Data Format	Internal J.O.D.C. (provide complete documentation)
Cruises Names	OFF8601, OFF8602
Storage Media	9-track tape
Density	6250 BPI
Character Code	ASCII or EBCDIC (only)
Record Size	120 bytes
Block Size	1920 bytes
Other Media Specific Information	(if applicable)
Cruise Information	MGD77 Header Coding Forms
Comments	Anything that will assist DCDB staff in the data processing.

Appendix 2 to Annex A

Data Range limits

DATA PARAMETER	ALLOWABLE RANGE
Latitude	90° to -90°
Longitude	180° to -180°
2-way Travel Time	greater than 0 less than 15 seconds
Corrected Depth	0 to 11,000 meters
Magnetic Total Field	20,000 to 72,000 nanoteslas
Gravity	977,000 to 985,000 mgals.

PART 2

BATHYMETRIC DATA MANAGEMENT

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CONTENTS

2A.1 - ROLE OF THE IHO VOLUNTEERING HYDROGRAPHIC OFFICES (VHOs)

2A.1.1 Any Hydrographic Office which has accepted the responsibility for centralizing oceanic soundings on bathymetric plotting sheets, on behalf of the IHO, shall, in the first place, endeavour to acquire all available bathymetric data and ascertain, by every means in its power, so that none have been overlooked.

2A.1.2 In this connection, Volunteering Hydrographic Offices (VHOs) shall normally :-

(1) collect all data from its own national sources;

(2) receive from other Hydrographic Offices - either directly or through the IHB - the data held by these Offices;

(3) receive, in accordance with agreements with the IOC which has recognized, by an IOC Resolution, the role of the IHO as the "World Data Centre for Bathymetry" - either directly, or through the IHB - all available bathymetric data from oceanographic missions carried out in accordance with declared national or international programmes;

(4) receive, each year, a copy of IHO publication B-4 (formerly BP-0004) "Information concerning recent bathymetric data" published by the IHB in accordance with IHO Technical Resolution A5.3. This list contains information on the existence of the most recent data collected on a worldwide basis either by the IHO Hydrographic Offices or by other national institutions. The VHOs must contact the originators of the data reported on these lists in order to include it in the bathymetric plotting sheets under their responsibility.

2A.1.3 The exchange of bathymetric data between IHO Hydrographic Offices is defined in IHO T.R. A5.2.

2A.1.4 VHOs shall exercise the greatest care in the choice of the soundings shown on their plotting sheets. It shall be the responsibility of each office to discern any abnormal soundings among the data available and to exclude them from the plotting sheets for which it is responsible. Soundings the positions of which are doubtful (PD) or approximate (PA), or the existence of which is doubtful (ED), or where no bottom has been found, shall not be included.

2A.1.5 Any Hydrographic Office compiling a particular plotting sheet is advised not to lose sight of the fact that it may be useful, with a view to avoiding omissions, to consult the standard navigational charts, particularly the INT charts at small scale, published by other Offices for the region to which the plotting sheets corresponds, and to enquire of such Offices, where deemed necessary, the origin and the reliability of any soundings on the charts that are considered to be of possible value.

2A.1.6 It is recommended that VHOs should not proceed with indiscriminate elimination of those soundings which can be referred to as "vintage". These shall normally be eliminated and replaced, where possible, by more recent soundings. For regions where they are the only bathymetric information known, however, it is advisable to take them into account, after elimination by the Hydrographic Office concerned of any particular doubtful or abnormal soundings. Experience has shown that the number of soundings eliminated in this way represents a very low percentage of the "vintage" soundings.

2A.1.7 It is recommended that each responsible Hydrographic Office keep up to date its own plotting sheets in as regular a way as possible, but at least once a year, in order to avoid an accumulation of unexploited data which it would subsequently be difficult to include in the plotting sheets, should there be an unforeseen demand by users for copies.

2A.1.8 When a plotting sheet and its annexed document(s) are published or brought up to date, the responsible Hydrographic Office shall forward at regular intervals one copy of each document to the IHB.

2A.1.9 The Hydrographic Office responsible for the preparation of a particular plotting sheet should supply users, upon request either directly or through the IHB, with copies of that plotting sheet at cost price.

2A.1.10 Details concerning the supply of copies of plotting sheets to the IHB by each Hydrographic Office concerned when a new edition of the GEBCO is due, are given in paragraph 2A.7.

2A.1.11 It is recommended that each VHO include in its catalogue of charts an index of the plotting sheets for which it is responsible, along with the relevant information (particularly dates of bringing up to date) and the price of copies.

2A.1.12 It is strongly recommended that each VHO notify the IHB of any comments it may wish to make concerning the documents for whose preparation it is responsible.

2A.2 - ROLE OF THE IHO's REMAINING (NON-VOLUNTEERING) HYDROGRAPHIC OFFICES

2A.2.1 All non-Volunteering Hydrographic Offices should :-

(1) bear in mind the IHO's role as a "World Data Centre for Bathymetry"

(2) send to the appropriate volunteering Hydrographic Offices (VHOs) - either directly or through the IHB - all releasable data in their possession.

(3) liaise closely with their other national institutions or bodies in order to obtain the data which they may have collected, and send it to the relevant VHOs.

2A.2.2 By Decision 42, the XIIth I.H. Conference recommended that when ships are operating in areas where data densification is required in order to improve the interpretation of the ocean bottom topography, they should be urged to arrange their tracks so as to improve the density of data.

2A.3 - BATHYMETRIC PLOTTING SHEETS - SOUNDINGS

2A.3.1 The original Bathymetric Plotting Sheets are prepared by IHO volunteering Hydrographic Offices (VHOs) which are responsible for centralizing all oceanic soundings for the zone for which they have accepted responsibility (IHO Technical Resolution A.5.3).

2A.3.2 The Bathymetric Plotting Sheets shall be drawn up on transparent plastic material, at 1:1M (or 1:250 000 in the case of plotting sheets for Regional International Bathymetric Charts), using the boundaries as shown on the "Catalogue of IHO Bathymetric Plotting Sheets" (formerly Publication BP-0002), published by the International Hydrographic Bureau (IHB), where the areas of responsibility and the various systems used by the VHO's are also described.

2A.3.3 The system of sheet boundaries for the Bathymetric Plotting Sheets is also shown on the British Admiralty's Chart No. 5330 "The World, Index of Plotting Sheets Areas for Oceanic Soundings".

2A.3.4 Accuracy standards for the soundings shown on plotting sheets shall normally be the ones indicated, for deep sea soundings, in the IHO Special Publication 44 "IHO Standards for Hydrographic Surveys - Classification Criteria for Deep-Sea Soundings and Procedures for Elimination of Doubtful Data".

2A.3.5 Soundings should be expressed in corrected metres (using either measured instrumental values for the speed of sound in seawater or recognized correction tables, and where appropriate tidal factors). The "Echo-Sounding Correction Tables" (NP-139), published by the British Hydrographic Office, or a computerized version of these tables, can be used (see Annex A of Part 3). IHO Special Publication 46 "Correction of Echo Soundings" can also profitably be consulted.

2A.3.6 The margin of each bathymetric plotting sheet shall contain the following items of information :-

(1) the identification number;

(2) the legend : "Published by the Hydrographic Office of ..... for the International Hydrographic Organization. Last brought up to date on ....."

(3) the scale of the plotting sheet;

(4) the legend : "Soundings in metres and corrected from ..... "

2A.3.7 The plastic material and the ink used for the plotting sheets shall be such as to enable these documents to be clearly reproduced.

2A.3.8 The coastline (including islands, islets, and rocks) shall be drawn. Islets and rocks of very limited extent, however, may simply be portrayed by the symbol for a danger enclosed within a dotted line.

2A.3.9 No geographic name shall appear on the sea areas of plotting sheets, except in the case of islands of limited extent when these constitute the only land areas on the plotting sheet concerned.

2A.3.10 It is strongly recommended that Volunteering Hydrographic Offices exercise particular care in inscribing soundings figures on plotting sheets. Such figures should be easily readable, the recommended average size being 1.5 to 2mm in height. The position of the sounding shall be the central point of the group of figures representing it. But the position may also be indicated by a dot with the soundings figure alongside, and if necessary, a line drawn to connect the two.

2A.3.11 The largest possible number of soundings shall be shown on plotting sheets so long as their clarity is not impaired. When soundings are very dense, their number may be reduced if care is taken not to eliminate the more important soundings : maxima or minima.

Except where automatic plotting processes make a particular arrangement of figures necessary, it is recommended that sounding figures be printed all at the same angle, preferably horizontal for easy reading; however, if tracks are in an East-West direction, or almost so, it is recommended that the figures be entered in a slightly slanted direction so that a greater number of soundings can be more easily inserted and read.

2A.3.12 Along the coastline, within the 200-metre isobath, a reduced selection of soundings shall be included, in areas where the continental shelf extends rather far out to sea.

2A.4 - BATHYMETRIC PLOTTING SHEETS - SOURCE OVERLAYS

2A.4.1 Each original bathymetric plotting sheet shall be accompanied by a source overlay on which shall be drawn all sounding lines and positions of isolated soundings with the appropriate legends or symbols required to indicate the source and the date of such soundings.

2A.4.2 This document shall bear in the margin all items of general information necessary for its identification with the original bathymetric plotting sheet (see paragraph 2A.4.6).

2A.5 - BATHYMETRIC PLOTTING SHEETS - UNIFORMITY AND ACCURACY OF SOUNDINGS AND POSITIONS

2A.5.1 In addition to the criteria for "deep sea soundings" shown in the IHO Special Publication 44, it is obviously desirable that soundings should be plotted in a uniform manner; i.e. that they all be :

(1) expressed in the same unit of measurement, preferably in metres. It is understood that those Hydrographic Offices that have not yet adopted this unit may continue on a provisional basis to supply plotting sheets on which soundings are expressed in fathoms;

(2) corrected for hydrological, instrumental, and tidal factors. All relevant information shall appear in the margin of each plotting sheet (see paragraph 2A.3.6).

2A.5.2 It is also advisable that plotting sheets show only those soundings that fulfil the accuracy requirements of the IHO, which implies that the responsible Hydrographic Office will be in possession of adequate information concerning :

(1) the nature of the sounding equipment used, the degree of accuracy of its calibration, and the way in which corrections have been carried out for instrumental, hydrological, or other factors;

(2) the methods used to determine the position of the vessel carrying out the sounding operation and the degree of accuracy actually observed in the determination of such positions.

2A.5.3 Since the ideal conditions as described in paragraphs 2A.5.1 and 2A.5.2 above may, in practice, be fulfilled only in the case of recent sounding operations carried out by specialized vessels and trained crews, and since overstrict requirements in this connection would lead to the elimination of any data that it was not possible to check fully, as regards method of collection and accuracy, but which were, however, sufficiently exact to constitute useful information leading to improved knowledge of the sea bed, the responsible Hydrographic Offices shall necessarily find themselves obliged to include simultaneously on plotting sheets soundings fulfilling either one or the other of the criteria referred to above.

Consequently such Offices are advised to take whatever action they consider to be most appropriate so that discrimination can be easily made between those soundings for which all the relevant information is available, and those for which such information is lacking to a greater or lesser degree. Such a result may be obtained, for example, by using a different type of print for each category of soundings, or by means of separate overlays showing the tracks followed by vessels which meet the requirements in 2A.5.2 above and those which fail to do so, or by any other appropriate method. This precautionary measure will facilitate the subsequent elimination from plotting sheets of the less reliable soundings as more accurate soundings obtained by modern methods become more numerous and widespread.

2A.6 - BATHYMETRIC PLOTTING SHEETS - SUPPLY OF COPIES TO THE IHB AND TO USERS

2A.6.1 Copies of plotting sheets and the documents annexed to each shall be supplied to the IHB by the responsible Hydrographic Office, either on transparent plastic material or on good quality paper.

2A.6.2 When a plotting sheet and its annexed documents are published or brought up to date, the responsible Hydrographic Office shall send a copy of each to the IHB.

2A.6.3 When a new edition of the GEBCO is due to be published in accordance with the programme established by the Joint IHO-IOC Committee for GEBCO, each Hydrographic Office concerned shall send to the IHB, when requested to do so, for each plotting sheet for which it is responsible, two copies of the sheet of soundings and one copy of the overlay indicating their sources.

2A.6.4 The Hydrographic Office responsible for preparation of a particular plotting sheet should supply users, upon request either directly or through the IHB, with copies of that plotting sheet at cost price.

2B.1 - THE IHO DATA CENTRE FOR DIGITAL BATHYMETRY

2B.1.1 The IHO serves as the World Data Centre for Bathymetry. The management of digital hydrographic data is carried out on behalf of the IHO by the IHO Data Centre for Digital Bathymetry (DCDB). The role of the DCDB is defined in Part 1, paragraph 1.7.2.

2B.1.2 *An* explanation of the services to be provided, together with operational procedures, systems and formats to support the data banking of digital bathymetry, at the DCDB, is given in Annex A of Part 1.

2B.1.3 All HOs are invited to send digital data to the DCDB. The incentives for doing this are threefold: firstly, by participating in this activity HOs can increase the data in the DCDB, in their area of interest, upon which they may draw data free of charge; secondly, by contributing data to the DCDB, HOs will later share the benefit of any paper or digital products that may emerge from the GEBCO Digital Atlas; and lastly, they have the security of knowing that if, by accident, they were to lose their own data, a replica set would be available from the DCDB.

2B.2 - ROLE OF THE IHO HYDROGRAPHIC OFFICES - (DIGITAL DATA)

2B.2.1 **Collection of Data**

2B.2.2 Each Hydrographic Office shall normally:

(1) collect digital data from its own national sources, and whenever possible send a copy to the DCDB;

(2) actively encourage other national collectors of digital data to send a copy to it or directly to the DCDB;

(3) convert to digital form, incoming analogue data on a cruise basis; (see Annex A)

(4) take into account the data listings provided in the IHO publication B-4 (formerly BP-0004) "Information concerning Recent Bathymetric Data" published by the IHB in accordance with IHO Technical Resolution A5.3. Part 2 of B-4 will list digital data forwarded to the DCDB in the preceding 12 months;

(5) ensure that it has the capability to read the MGD77 format used by and available from the DCDB for data distribution.

2B.2.3 **Quality Control of Data**

2B.2.4 The organisation, formatting and documenting of digital data should conform with the guidelines given in Part 3, and checks should be undertaken to ensure that the data appear reasonable. In particular, the time variation of the ship's speed and course, as derived from the ship's position, should be checked and any major discontinuities or anomalous characteristics should be carefully examined. Similarly, major discontinuities in the depth profile should be investigated and, wherever possible, the depths should be checked against other soundings available for the area. Where practicable, errors should be resolved by recourse to the data originator before the data are submitted to the DCDB. A statement of the checks made should be included with the documentation accompanying the data and any unresolved errors or suspicions about the data should be clearly identified.

2B.2.5 Where possible the HOs should attempt to ensure that all data provided to the DCDB are accompanied by a statement on the estimated quality and accuracy of the data (see 2B.2.6 - 2B.2.8 below). The application of a standard method of quality control allows comparison of the reliability of new and existing data. HOs may thus remove data with a relatively poor reliability rating, or data found to be in error.

2B.2.6 In addition to the criteria for "deep sea soundings" shown in the IHO Special Publication 44, it is obviously desirable that soundings should be recorded in a uniform manner", i.e. that they all be:

(1) expressed in metres;

(2) corrected for oceanographic instrumental, and tidal factors.

2B.2.7 It is also advisable that HOs and Institutions collect only those soundings that fulfil the accuracy requirements of the IHO, which implies that the responsible HO or Institution will be in possession of adequate information concerning:

(1) the nature of the sounding equipment used, the degree of accuracy of its calibration, and the way in which corrections have been carried out for instrumental, oceanographic, or other factors;

(2) the methods used to determine the position of the vessel carrying out the sounding operation and the degree of accuracy actually observed in the determination of such positions.

2B.2.8 Notification of deleted data should be passed by the HO to the DCDB, which will amend its own records. In addition, if the HO determines that revisions are required to data already provided to the DCDB, new versions of the data should be sent to the DCDB. They should include sufficient documentation that identifies the problem and the data affected. In turn, the DCDB should send a list of such deleted and revised data to the IHB for inclusion in Part 2 of the annual publication B-4.

2B.2.9 HOs should retain their own files of deleted data, for possible future use as a research resource or as a check against the reappearance of such data in other agencies' files.

2B.2.10 **Provision of Data to the DCDB**

2B.2.11 All digital data provided should preferably be time-sequenced on a cruise-by-cruise basis and, wherever possible, port-to-port in extent. Data should also be correctly identified and meet the guidelines for quality control and should be provided to the DCDB provided:

(1) it is national data and has not previously been passed to the DCDB;

(2) if it is not national data, and has not already been sent to the DCDB, ensure that proper authority to provide it to the DCDB has been obtained.

2B.2.12 Data should be provided to the DCDB regularly, although it may be most practical to batch the data over a period of months. Only data which have reached the DCDB by 31 October will be listed in the next issue of B-4.

2B.2.13 MGD77 is the preferred format for data, but the DCDB will, by agreement, accept data in other formats if adequate documentation is provided (see Annex A of Part 1). For details of acquisition of formats MGD77 and GF3, See paragraph 3.1.3 of Part 3.

2B.3 - ADDITIONAL ROLE OF THE IHO VOLUNTEERING HYDROGRAPHIC OFFICES - (DIGITAL DATA)

2B.3.1 In respect of Data Collection and Quality Control, the roles of and incentives to the VHOs are identical to those of the HOs. However, two additional tasks are requested of the VHOs: Validation of Data and Conversion of Oceanic Plotting Sheets to Digital Form; these are described below. Additionally, for those VHOs awaiting digital capabilities, advice is also given.

2B.3.2 **Validation of Data**

(1) VHOs are requested to maintain digital data banks within their own geographic area of responsibility; these provide a base against which new data are validated.

(2) Validation is generally carried out by making comparisons between the new and existing data sets. The manner of this comparison is a matter of choice for the VHO. The aim is to ensure correct data.

(3) The VHOs are also requested to validate (from 1993) retrospectively all data within their area of responsibility which has been sent to the DCDB by others during the previous 12 months. Details of these data will be published annually in IHO B-4 (formerly BP-0004).

(4) In the case of successful validation, the VHO should inform the DCDB that the data have been validated.

(5) If the validation identifies possible errors between old and new data, enquiries should be made to the originators of one or both data sets. The outcome of the enquiries should be assessed by the VHO and their conclusions sent to the DCDB and copied to the originators.

(6) For GEBCO purposes, VHOs are no longer to update Oceanic Plotting Sheets (OPS), but see also 2B.3.6.

Footnote (i) It is recognised that some VHOs may not be able to meet with the request to validate all or any of the data in their area of responsibility. It is hoped that, in the passage of time, automatic procedures will enable this task to be undertaken.

(ii) Where data conflicts cannot be resolved it may be necessary to defer decisions until new data are acquired.

2B.3.3 **Conversion of Oceanic Plotting Sheets to Digital Form**

2B.3.4 VHOs which retain some of their older data in analogue form are encouraged to convert these to digital form in order to increase the holdings of the DCDB.

2B.3.5 Conversion programmes may be carried out in stages to satisfy particular internal priorities or responsibilities. When designing digitizing programmes, VHOs should bear in mind the following points:

(1) For GEBCO support purposes, priority should be given to data collected with modern accurate navigation and depth recording systems. However, older data are still important in data sparse areas.

(2) Advice from the DCDB should be sought to identify data already available in digital form.

(3) To ensure maximum accuracy, data should be digitised from the original Plotting Sheet, rather than from the OPS (see Annex A).

(4) Details for the quality control of digital data and its submission to the DCDB are given in paragraphs 2B.2.4 and 2B.2.9 respectively.

2B.3.6 **VHOs Awaiting Digital Capability**

2B.3.7 These VHOs should continue to update their OPS in accordance with Part 2A of this publication.

2B.3.8 If VHOs wish to receive plots from the digital data listed in B-4, Part 2, they should apply only to the HO or institution holding the original data. If such data are added to their OPS, they should be clearly identified to prevent re-digitization at a later date.

2B.3.9 These VHOs should continue to advertise analogue data in B-4, Part 1. They should be prepared, on request by another VHO with digitizing capabilities, to pass copies of the plotted or raw analogue data for digitization.

2B.3.10 The IHO wishes to encourage all VHOs to adopt digital methods for collecting, storing and exchanging bathymetric data. VHOs requiring any assistance in setting up their own digital data programmes should contact the IHB.

2B.3.11 VHOs should bear in mind that, for GEBCO purposes, all analogue OPS will be phased out by 1996.

2B.4 - IHO B-4 (formerly BP-0004) - INFORMATION CONCERNING RECENT BATHYMETRIC DATA

2B.4.1 The annual IHO publication B-4 (formerly BP-0004), in addition to listing analogue data in Part 1 (see also 1.7.1(8)), will from 1993 contain a new Part 2 - Digital Data.

2B.4.2 This second part will consist of:

(1) a catalogue of digital data received by the DCDB in the preceding 12 months. (see 1.7.2(4));

(2) a list of digital data found to be in error by the originators of the data; or deleted by a VHO, due to relatively poor reliability;

(3) a list of data that has been corrected and re-submitted.

2B.5 - MULTI-BEAM DATA

2B.5.1 The subject of multi-beam digital data management will be described in Part 4 of this publication at a later date.

ANNEX A

ACCURACY CATEGORIES FOR DATA DIGITIZED FROM SHIPS' PLOTTING SHEETS

Where positions are digitized from a "ship's plotting sheet", the scale of the sheet sets an upper limit on the accuracy of the positions.

The accuracy categories from S-44 (formerly SP-44), Chapter 2 on "Classification Criteria for Deep Sea Soundings" are:

(a) Category D (better than 100m) - for scales 1:1,000 - 1:60,000

(b) Category E (better than 500m) - for scales 1:61,000 - 1:300,000

(c) Category F (better than 2km or 1.0 NM) - for scales 1:301,000 - 1:1,250,000

(d) Category G (better than 10km or 5.0 NM) - for scales 1:1,251,000 - 1:5,000,000

Where positions are digitized from a subsequent replotting of the original (e.g. an OPS), the positional accuracy is likely to be of a lower order.

PART 3

DIGITAL BATHYMETRIC DATA (SINGLE-BEAM ECHOSOUNDERS)

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CONTENTS

3.1 - INTRODUCTION

3.1.1 This chapter is concerned primiraly with the storing and documenting of digital deep sea (>100m) data from single beam echosounders. It is recognised that magnetic field and gravity data are often collected simultaneously with echosounder data and there are good reasons for maintaining these data together with the sounding and navigation data. When magnetic and gravity data are also collected the contents of this chapter should be read in conjunction with Part 5 of this publication which gives guidelines for storing and documenting underway magnetic and gravity data.

3.1.2 The MGD77 format and the GF3 format are the preferred magnetic tape formats for the exchange of underway bathymetry (single beam), magnetic field and gravity data expressed in digital form. The guidelines presented in this chapter are compatible with these forms. The documentation standards for navigation and bathymetry are also compatible with the requirements of IHO Special Publication No. 44, Chapter 2 on "Classification Criteria for Deep Sea Soundings".

3.1.3 Detailed descriptions of the formats MGD77 and GF3 can be obtained from the following addresses:

- MGD77 format

IHO Data Centre for Digital Bathymetry (DCDB)
National Geophysical Data Center (NGDC)
NOAA E/GC3
325 Broadway
Boulder, Colorado 80303 - 3328
U.S.A.
Telefax: +1 (303) 497 6513
Telex: 592811 NOAA MASC BDR

- GF3 format

1) Intergovernmental Oceanographic Commission (IOC)
UNESCO
Place de Fontenoy
75700 Paris
FRANCE

Telefax: +33 (1) 47 83 59 40
Telex: 204461 PARIS

2) British Oceanographic Data Centre (BODC)
Proudman Oceanographic Laboratory
Bidston Observatory
Birkenhead
Merseyside L43 7RA
UNITED KINGDOM
Telefax: +44 (51) 652 3950
Telex: 628591 OCEANB G

3.2 - GUIDELINES FOR DATA ORGANISATION

3.2.1 It is recommended that the data should be stored on a cruise by cruise basis and that the data for each cruise should be organised in the form of a time series. A cruise is usually considered as a port-to-port operation - on occasions this may be synonymous with a cruise leg or "survey". Alternatively, the data may be grouped for convenience into surveys or survey legs. The important concept to maintain is that the grouping should relate to a specific vessel and to a specific period of time. It is recommended that the data be arranged in ascending sequence of date/time rather than as a spatial progression of positions and their associated depths. The time information provides for the possibility of valuable quality control checks and correlation with other associated data sets.

3.2.2 The data for each "cruise" should be stored as a single time series into which is merged navigational information and the bathymetric depths. Where available, underway measurements of the earth's magnetic and gravity fields should also be merged into the time series - the collection of these auxiliary parameters is strongly encouraged.

3.2.3 It is recognised that, in the initial stages of data preparation, separate time series may exist for the navigation, bathymetry, magnetics and gravity data. Indeed, the navigation data may exist with separate time series for the fixes from each navaid and a further time series of course and speed. It is essential that the navigation should be worked up into a single best fit track for the cruise such that geographic position (latitude and longitude) is directly available as a unique function of date and time - separate navigation files should not exist for the bathymetry, magnetic and gravity data (the vessel can only be in one position at a given time!!!). The final navigational time series should contain sufficient points such that when the bathymetry, magnetic, gravity etc. data time series are merged into it (with data at intervening times) the geographic position at each measurement time can be derived by simple interpolation.

3.2.4 In the preparation of the best fit navigation time series for the cruise and the subsequent merged data time series, it is recommended to retain and clearly identify within the series all good prime navaid fixes and turning points, irrespective of whether other measurements were collected at these times.

3.2.5 When other underway information is collected simultaneously with the time series data - for example seismic profiling, multibeam or swath-type echosounding etc. - the start and stop times for these data should be encoded within the time series so that automated track inventories may be maintained for these additional data types.

3.2.6 Whereas the time labelling of data is strongly encouraged, it is recognised that, on some surveys, shot point numbers, event marks or some other fiducial reference may be used in place of ship's time - in such cases the data should still be maintained in a sequential time-ordered form.

3.2.7 An essential part of any digital data series is the documentation describing how the data were collected and processed, the instrumentation used, the reference datum, the methods used for correcting the data, the originator's assessment of the quality of the data, the notification of instrument malfunctions or other effects influencing the quality of the data etc. It is strongly recommended that such documentation be stored in computer compatible form together with the data.

3.3 - ECHOGRAM DIGITIZATION

3.3.1 One of the weaknesses of the present day process of reporting deep sea soundings is that only a small part of the continuous sea bed profile is presented. If the data are archived on 1:1 million collected soundings sheets there is an obvious limit on the number of soundings that can be clearly displayed along the track. However, with digital storage there are no such limitations, although techniques are not yet available for storing all the information in the echosounding trace in an easily usable form.

3.3.2 It is recommended that, in preparing data in digital form, as much information should be extracted as to ensure that straight lines between the digitized soundings agree with the actual seabed within the tolerance established by the sounding accuracy - this implies that all peaks, deeps and points of change of bottom slope should be digitized. Where practical considerations prohibit this level of data extraction, the original echograms or flow-film microfilm should be safely preserved in national or institutional archives.

3.3.3 Where data have been manually digitized it is important to check for any transcription errors that may have occurred in logging values or in keying them into computer compatible form. Particular care should be taken to avoid introducing errors at changes in the echogram recording scale. Data collected using a digitizer associated with an echosounder should also be subjected to close scrutiny.

3.4 - CONTENTS OF DIGITAL DATA FILES

The preferred formats for data exchange are the MGD77 format or the GF3 format. In order to maintain compatibility with these formats, the following guidelines should be adhered to in the design of any format for the storage of underway geophysics data.

3.4.1 For exchange purposes the data should be stored in character format (ASCII or EBCDIC) in fixed length records with fields in integer or fixed point format (or alphanumeric format for flags) in fixed positions within the record. Each record should at least contain fields compatible with the following items. (Note that the high precision to which fields are stored is not a reflection of expected data accuracy but is rather to maintain relative precision between adjacent readings):

3.4.2 Date/Time: should be expressed in UT and include year (YYYY), month (MM), day of month (DD), hours (HH) and either minutes to thousandths (MM.MMM) or minutes with seconds to hundredths (MMSS.SS).

3.4.3 Geographic Position: should be expressed as a latitude and a longitude either in:

i) degrees to hundred thousandths, i.e. +/- DD.DDDDD (or +/- DDD.DDDDD) or

ii) degrees and minutes to ten thousands, i.e. +/- DD +/- MM.MMMM (or +/- DDD +/- MM.MMMM)

The fields should be signed according to the convention North and East positive. For option ii) minutes and degrees should be treated as additive, i.e. both should be signed (the prime reason for signing minutes as well as degrees is to avoid ambiguities within a degree either side of the equator or the Greenwich meridian). In creating tapes for exchange, avoid minus zero (-0) as this cannot be read on some computers.

Although optional the following two items are recommended for flagging the quality of the geographic position:

3.4.3.1 Fix indicator: a single character flag field set to 'F' if the geographic position is the direct result of a good prime navaid fix - otherwise left blank.

3.4.3.2 Position quality: may be expressed in one of two forms:

i) using a one character flag indicating whether or not the position is considered suspect by the originator (e.g. blank = unspecified; "A" = acceptable; "S" = suspect) - supporting documentation will normally be provided to explain why positions are considered suspect; or

ii) using an error ellipse expressed in terms of its semi-major and semi-minor axes and major axis azimuth, and calculated according to a specified confidence level. For the present, this use will normally be for TRANSIT satellite fixes but, as navigation techniques develop, it may be used to assign an error ellipse to each point along the track that can then be used to determine how much each point can be shifted. The method of determination, and confidence level, of the ellipse should be described in the supporting documentation.

3.4.4 Bathymetric Depth

There are a number of different common practices for storing depth values from echosoundings depending on how the problem of correcting (or not correcting) the depth for the true speed of sound through the water column is addressed. It is strongly recommended that one, or a combination of the following standard fields should be used:

3.4.4.1 Corrected depth: expressed in metres to tenths (MMMMM.M) and standardised on the Third Edition Echo-Sounding Correction Tables (see Annex A) unless more accurate local or in-situ measurements of sound velocity are available.

3.4.4.2 Uncorrected two-way travel time: expressed in seconds to 0.0001 secs (SS.SSSS).

3.4.4.3 Uncorrected depth: assuming a nominal sound velocity of 1500m/s and expressed in metres to tenths (MMMMM.M) - **use of a nominal sound velocity of 800 fms/s is strongly discouraged**.

3.4.4.4 Whichever standard is used it is essential that the data are accompanied by a clear and unambiguous statement of the standard used, of the corrections that have been applied and of the sound speed setting of the echo sounder. It is strongly recommended that the depth is corrected for the transducer depth and, if possible, for the state of the tide (shallow water only i.e. in water depths of less than 200m).

3.4.4.5 If a valid depth value is missing, e.g. the record coincides with other measurements (magnetic field, gravity or simply a navigation fix), an appropriate null value should be entered in the depth fields. It is recommended to standardise on zero as the null value for the depth fields - whatever null value is adopted should be consistently used throughout the series and clearly documented.

3.4.4.6 Bathymetry quality: a one character flag indicating whether or not the depth value is considered suspect by the originator (e.g. blank = unspecified; "A" = acceptable; "S" = suspect) - supporting documentation will normally be provided to explain why depths are considered suspect.

3.4.5 Magnetic Field Data (Optional): see 5.2

3.4.6 Gravity Data (Optional): see 5.3

3.4.7 Other Instrumentation (Optional): single character flags to indicate the availability of other underway information collected simultaneously with the time series, e.g. side scan sonar, multibeam or swath-type echosounding, seismic profiling. One flag should be assigned to each type of instrumentation so indicated. The following coding is recommended for the flag: '1' (one) - instrumentation in use; '0' (zero) - instrumentation not in use; blank - unspecified. The use of these flags provides an excellent method for generating track charts indicating the availability of other types of data, and for linking navigation information to the time base of these data.

3.5 - DATA DOCUMENTATION

It is essential, when data are exchanged, that clear documentation is provided defining precisely:

a) the format in which the data are stored and;

b) the conditions under which the data were collected and processed (data documentation).

The data documentation should preferably be stored in computer compatible form together with the data but, if this is not possible, it may be provided in hard copy form. The forms on the following pages serve two purposes:

a) as a ready made form for preparing hand-written documentation or;

b) as a checklist of the items of information that should be included in computer compatible form with the data.

There are three components to the documentation viz:

a) details about the cruise and platform;

b) information about the navigation data and;

c) information about the bathymetric data.

GENERAL DOCUMENTATION ABOUT THE CRUISE

INSTITUTION RESPONSIBLE FOR COLLECTING DATA :

NAME : . . . . . .

COUNTRY : . . . . . .

SHIP FROM WHICH DATA WERE COLLECTED :

SHIP NAME : . . . . . .

SHIP TYPE : . . . . . .

SHIP CALL SIGN : . . . . . .

LENGTH OF SHIP : . . . . . .

CRUISE IDENTIFIERS :

PROJECT : . . . . . .

CRUISE (LEG): . . . . . .
(OR SURVEY)

CHIEF SCIENTIST : . . . . . .

START DATE OF CRUISE/LEG/SURVEY - DD/MM/YY : . . . . . .

END DATE OF CRUISE/LEG/SURVEY - DD/MM/YY : . . . . . .

PORT OF DEPARTURE (name and country) : . . . . . .

PORT OF ARRIVAL (name and country) : . . . . . .

PURPOSE OF CRUISE AND BRIEF NARRATIVE :

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SUPPORTING DOCUMENTATION FOR NAVIGATION DATA

NAVIGATION SYSTEM : systems should be clearly identified - avoid general terms such as satellite navigation or radio navigation systems - more precise information is required (e.g. Decca Hifix, LORAN C, GPS etc.).

* Prime Navaid : . . . . . .

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* Secondary Navaids : . . . . . .

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DATUM : differences between geodetic datums, local datum and geocentric satellite navigational datum may amount to several hundred metres. It is important, therefore, that the datum should be specified when the geographic accuracy is better than 500m, either by a recognised term (e.g. "Tokyo datum", WGS84) or by quoting the reference ellipsoid constants a and 1/f and the datum translation components X_o, Y_o and Z_o that give the coordinates of the centre of the datum relative to the geocentre.

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METHOD OF DETERMINING ALONG TRACK POSITIONS :

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ACCURACY ASSESSMENT : estimate the geographic accuracy of 95% of the navigation fixes circling one of the following:

<50m <100m <500m <2km <10km >10km

ADDITIONAL COMMENTS : include any additional information that has a bearing on the quality of the navigation, e.g. a) average number of good prime navaid fixes/day; b) identify any periods of suspect navigation (e.g. due to instrument malfunctions or lack of good fixes); c) relative position accuracy between tracks (for systematic surveys of large areas) etc.

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SUPPORTING DOCUMENTATION FOR SINGLE BEAM ECHO SOUNDING DATA

NAME AND TYPE OF ECHO SOUNDER : . . . . . .

TOTAL BEAM WIDTH (between the -3db points) : . . . . . .

ECHO SOUNDING SIGNAL FREQUENCY (kHz) : . . . . . .

TIMING ACCURACY (% of travel time): circle one of the following: <0.1% <1% <2% >2%

INSTRUMENTAL SAMPLING RATE (soundings/sec) : enter the instrumental sampling rate or sweep rate i.e. the rate at which the data were originally collected. N.B. This is not the same as the digitization rate which, if regular, is entered under 'Sounding Selection Criteria'.

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SOUNDING SELECTION CRITERIA : indicate the criteria used for extracting depth values from the echogram - such as a) peaks and troughs; b) points of change in slope; c) sea bed smooth between soundings within specified limits; d) values extracted at given time intervals - the interval should be specified; e) spot soundings etc.

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NOMINAL SOUND VELOCITY OF ECHO SOUNDER : . . . . . .

PROCEDURES FOR CORRECTING FOR SOUND VELOCITY : state clearly whether the soundings were corrected for sound velocity and, if so, by which method e.g. a) in situ measures at the time of survey; b) Third Edition NP139 of the Hydrographic Department of the UK (recommended at the XIIth IHC, Monaco, 1982),; c) Second Edition NP139 - Matthews Tables; d) other (please specify).

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DATUM CORRECTIONS : it is assumed that a) corrections will have been made for transducer depth (if not, then this should be clearly indicated, together with the transducer depth). Note - for towed transducers this may vary with ship speed and should be continually monitored; b) corrections will not have been made for the height of the tide unless appropriate (e.g. over seamounts or in shallow water) - any corrections made should be clearly indicated, together with the tidal datum.

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ADDITIONAL COMMENTS : report on malfunctions, errors or any other factors that have a bearing on the quality of the data.

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ANNEX A

THIRD EDITION ECHO-SOUNDING CORRECTION TABLES

In 1980 the Third Edition of Echo-Sounding Correction Tables was published by the Hydrographic Department of the UK to replace the tables of the Second Edition, commonly referred to as Matthews Tables, for the correction of echo-soundings for the varying speed of sound in sea water. The tables were extensively revised to incorporate the large number of temperature and salinity measurements obtained since 1939, and use an improved formula for the speed of sound in sea water derived in recent years. Computations for the revised tables were carried out by D.J.T. Carter of the Institute of Oceanographic Sciences Deacon Laboratory, Wormley, Surrey, using oceanographic station data provided by the United States National Oceanographic Data Center, Washington.

The XIIth International Hydrographic Conference at Monaco in 1982 decided to adopt the Third Edition Tables in place of Matthews Tables. The revised tables, together with a detailed description of their preparation, are contained in 'Echo-Sounding Correction Tables: Third Edition N.P. 139' published by Hydrographic Department, Ministry of Defence, Taunton, in 1980. This publication is available from Admiralty Chart Agents, whose addresses may be obtained from UK Hydrographic Office, or directly from:-

The Sales Section
Hydrographic Office
Ministry of Defence
Taunton, Somerset, TA1 2DN
UNITED KINGDOM
Telefax: +44 (0) 823 284 077
Telex: 46274 (Answer back: Navhyd G)

The revised tables are applicable for use throughout the world in water depths of greater than 200 metres, and cover depth to the sea bed in each of 85 echo-sounding correction areas. As the boundaries between echo-sounding correction areas lie along exact degrees of latitude and longitude, the tables are particularly suited for automatic use on computerised systems. Although the published tables are listed at 10 metre intervals, values between 100 metre intervals were derived by linear interpolation, so only 100 metre values need be stored for access by a computer program.

A computerised version of the Third Edition Tables is now available, enabling echo-soundings to be corrected automatically given the ship's position. It contains copies of the two Fortran 77 sub-routines necessary to produce the corrections, together with the requisite data, i.e. the computerised echo-sounding correction area definitions and correction tables. The sub-routines and their data are designed for portability between different computer systems, and are obtainable on magnetic tape or floppy disk from:-

i) British Oceanographic Data Centre (BODC)
Proudman Oceanographic Laboratory
Bidston Observatory
Birkenhead
Merseyside, L43 7RA
UNITED KINGDOM

Telefax: +44 (51) 652 3950
Telex: 628591 OCEANB G

(at a charge of £50 sterling)*

or ii) IHO Data Centre for Digital Bathymetry
(DCDB)
National Geophysical Data Center
(NGDC)
325 Broadway
Boulder, Colorado 80303 - 3328
U.S.A.
Telefax: +1 (303) 497 6513
Telex: 592811 NOAA MASC BDR

(at a charge of $100 U.S.)*

* charges made to defray costs of copying the tape and postage/packing; subject to change.

D **R A F T**

PART 4

DIGITAL BATHYMETRIC DATA (MULTIBEAM ECHO SOUNDERS)

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CONTENTS

4.1 - INTRODUCTION

4.1.1 This Part concerns the storage and documentation of digital bathymetric data from multibeam echo sounders. Other geophysical data such as magnetic and gravity field strength data are often collected concurrently with bathymetry. While there are good reasons for maintaining such data together to include the sounding and navigation data, this is no longer the case when full-resolution multibeam bathymetry is collected. When such other geophysical data are concurrently collected, this Part should be read in conjunction with Parts 3 and 5, which provide guidelines for storing and documenting underway single beam bathymetry and magnetic and gravity data. Also, note the recommendation in paragraph 4.4.8.

4.1.2 Nomenclature related to bathymetric data has sufficient ambiguities that clarification of the specific meanings intended within this Part is warranted. See Annex A discussion and definitions concerning: 1) accuracy, precision and resolution, 2) cruise and survey, and 3) course and heading.

4.1.3 Optimal data structures can be defined in terms of the functions for which they are used. Structure is different from information content. The structure in which data are collected, stored, archived, exchanged or analyzed plays an important role in the efficiency of those different functions. In the function of data collection, the data structure must be matched to the volume of data flow, and data collection must not be interrupted. The function of storage of data invokes another set of criteria to be met, centering on robustness of the storage process, with error tolerant or correcting structures that make provisions for less than perfect storage and recovery. Archiving of data has the primary criterion of long-term reliability, which invokes such concepts as redundancy, error correcting structures, self-description, and transparent readability, avoiding arcane compression algorithms or encoded data. The function of exchanging data requires yet another dimension of optimization. An exchange structure should be robust, reliable, readable, very stable, and complete and self-documented. The data structure used in processing or analysis must meet the needs of repeated and rapid access and transfer. These structures tend to be readily machine readable, and hence hardware specific. While all of these structures may have the same information content, they must trade off optimization of functional characteristics such as speed of access, speed of storage, data volume, and ease and universality of readability. Optimizing one set of functional characteristics necessarily means compromising on others.

4.1.4 Presently, there is no preferred data structure for the exchange of multibeam echo sounding data. While single beam echo sounding data are preferentially exchanged in the MGD77 format or the GF3 format, neither are suitable for the orders of magnitude greater amounts of data for each sounding point of multibeam bathymetry. A preferred data structure for the exchange of this class of multiple-valued echo sounding data remains to be developed. At the present time, numerous translation programs exist for reading and writing the multiple data structures used for the collection and processing of these data by the various agencies, institutions and companies involved with data collection. The guidelines presented in this Part and the data exchange structure under development will be compatible with the requirements of the IHO Special Publication S-44, Part 2, "Classification Criteria for Deep Sea Soundings."

(Note: Part 2 of the current S-44 is given as Annex A in revision 3 of the new Draft S-44 being considered by the IHO Working Group on S-44.)

4.1.5 The precision of units used to log multibeam data should be commensurate within the assembly of data and metadata recorded and not excessive so as to sacrifice economy of data volume. A coherent and inter-related grouping of data precisions can be rationalized with the following logic. Multibeam vertical and horizontal resolution have a maximum of about 0.1 metre. The 12 kHz bandwidth of most deep sea echo sounding systems implies a time resolution of 0.08 millisecond, which at a sound velocity of 1500 metres/second yields a vertical, spatial resolution of about 0.1 metre. Global Positioning System (GPS) navigation has a horizontal resolution commensurate with the GPS antenna dimensions of about 0.1 metre. The time resolution necessary to resolve 0.1 metre at a maximum ship's speed of 20 knots, is 0.0097 seconds, or about 0.01 second. The threshold resolution of speed to detect 0.1 metre of motion over a 10 second interval is 0.02 knots, implying sufficient resolution at 0.01 knot. Finally, a heading resolution of 0.1 degrees is sufficient to resolve 0.1 metre of displacement at a 30 metre (ship length) distance (3 milliradians or 0.2 degree). Thus, a coherent set of resolutions might be: length or depth to 0.1 metre, horizontal position to 0.1 metre (or millionths of a degree latitude and longitude); time to 0.01 second; and ship's heading to 0.1 degree.

4.2 - GUIDELINES FOR DATA ORGANIZATION

4.2.1 It is recommended that the data should be organized on a cruise by cruise basis, and within each cruise, the data be organized by survey area, the data within a survey should likewise be organized in the form of a time series, even though it may be an interrupted series. Because the volume of data derived from multibeam echo sounding are orders of magnitude larger than that derived from single beam echo sounding, it is necessary to subdivide the data into units of storage and exchange that are manageable in size and quantity, e.g., between 1 and 10 megabytes. Too large a file size results in system memory size problems; too small a file size results in an overabundance of files to be managed. The time-length of these units of storage and exchange will be determined by the collection rate of the echo sounding system. The guiding concept is to group the data arranged in ascending sequence of date/time rather than a spatial progression of positions and their associated depths. The time information is the essential, correlative link to: the navigational time series, the possibilities of quality assessment checks, and other associated data sets.

4.2.2 The data for each "cruise" should be stored as a sequence of subsets of contiguous, monotonically increasing, time series into which are merged the necessary navigational information, echo sounding positional information and depths. Given the orders of magnitude greater volume of multibeam data than other geophysical measurements such as gravity and magnetics, it is inadvisable to store these other data within the same data structure. The tremendous dilution of these other data would render their retrieval from amongst the multibeam data extremely inefficient.

4.2.3 During the initial stages of data collection and preparation, separate time series may exist for the navigation, bathymetry, magnetics and gravity data. The navigation data itself may be comprised of separate time series from each electronic navigation system and possibly a further, dead reckoning, time series of course and speed. It is essential that the navigation data should be post processed into a single, best fit track for the cruise, such that geographic position (latitude and longitude) is directly available as a unique function of date and time. This "best" navigation may include adjustments that reconcile bathymetry to self-consistency at spatial crossovers and consistency of spatial time derivatives with measured accelerations from gravity observations, when geophysical measurements are made in addition to bathymetry. The guiding principle is that a single navigation time series should apply for bathymetry, magnetics, and gravity; uncertainty notwithstanding, the vessel may occupy but one position at a given time. The final navigation time series should contain sufficient points such that when the data time series (bathymetry, magnetics, gravity, etc.) are merged with it, the geographic position at each measurement time can be derived with sufficient precision by simple interpolation.

4.2.4 In preparation of the best fit navigation time series for a cruise and the subsequent merged data time series, it is recommended that all good prime navigation fixes and turning points, irrespective of whether other measurements were collected at these times, be retained and clearly identified within the series.

4.2.5 Whereas the time labeling of data is strongly encouraged, it is recognized that, on some surveys, shot point numbers, event marks or some other fiducial reference may be used in place of time as the correlative parameter. In such cases, the data still should be maintained in a sequential, time-ordered form, and time should be included in the data with the other fiducial reference, if at all possible.

4.2.6 An essential part of any digital data series is the documentation describing how the data were collected and processed, the instrumentation used, the reference datum, the methods used for correcting the data, the originator's assessment of the quality of the data, the logging of instrument malfunctions, or other effects influencing the quality of the data, etc. Furthermore, in the case of multibeam bathymetry, environmental data, such as the water column sound velocity profile, are essential to interpretation and understanding the primary data. It is thus essential that such documentation, or metadata, be stored in the same data structure together with the primary data.

4.3 - DATA DIGITIZATION

4.3.1 Multibeam bathymetric systems, because of the beam geometries, ping rate, system configuration and nominal ship speed, tend to oversample depth along track and thus many digitizing programs will subsample the alongtrack components. This subsampling process should be directed toward achieving optimal sampling and not necessarily decimating the data for real-time processing constraints. Since the data are collected, stored, and retrieved digitally, the ability to physically display individual soundings is no longer a constraint; frequently all the data are summarized in contour, or gridded, form, based on all, or some reduced subset, of the data.

4.3.2 It is recommended that as much of the primary, multibeam, echo sounding data as practicable be recorded and preserved. Since these data are digital from the outset, traditional, analog, microphoto methods of archival are no longer practical. Instead, it is necessary to capture as much of the full-resolution ping data as possible, merge it with the "best" navigation data, and archive it as a set. While the primary data are the measured, two-way travel times at given beam angles, a much more usable data set consists of the across track and along track offsets from the given ship's position, the heading of the ship, and the corresponding depth values. These are either expressed as depths under an assumed mean sound velocity, e.g., 1500 metres/second, or as the actual measured depths taking into account the measured, *in situ*, sound velocity profile. Metadata reference to availability of beam and travel-time data is much preferable to the actual inclusion of the reduced data.

4.3.3 Metadata, supporting information, is far more essential to the correct and accurate interpretation of multibeam bathymetry than most marine geological and geophysical data. Since the non-vertical beams are subject to refractive effects of the water column, complete documentation of both the operational sound velocity profile used in the real-time processing of the multibeam data and the measured, *in situ* sound velocity profile, if different, are essential components of the data. In systems where beamforming is used to maintain a vertical transmit beam, the sound velocity of the water at the keel (ksv) is a crucial component of the metadata. Likewise, quality assurance procedures applied to the data should be documented in the metadata, especially those procedures that might alter the original character of the data, such as filters of detected errors, unreasonable slopes or noise spikes. Quality enhancement procedures such as along-track averaging must be recorded in the metadata to ensure valid interpretation of the data at times after the initial collection and processing. Cross referencing to regional topographic models and adjustments to navigation on the basis of track crossings must likewise be fully documented in the metadata. This history, or pedigree, of the data and its processing becomes an essential part of the metadata.

4.3.4 In conclusion, these data are now fully digital, generally positioned by fully digital navigation data. The metadata component becomes increasingly important as a digital logbook to accompany the digital, primary data, just as the scientific logbook once complemented the physical, analog recordings of depth, magnetics and gravity data.

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4.4 - CONTENTS OF DIGITAL DATA FILES

4.4.1 The preferred structures for exchange of multibeam data remain to be developed. Two major factors mitigate the immediate need for an exchange structure. First is the abundance of translators between the various extant multibeam formats. The second is the fuller appreciation that optimal data structures must follow function. The growing awareness of the users of multibeam data and the equipment on which these users operate are shaping the form, extensibility, and character of the data structure in which multibeam bathymetry will be ultimately exchanged. It is not merely a question of information content, which is essentially the same for the functions of collecting, archiving, and, largely, processing, as well as exchange. It is a question of optimizing a data structure to make access to and use of the data structure as efficient and straightforward as possible for the largest possible audience of users.

4.4.2 For exchange purposes, the data should be stored in character format (ASCII or EBCDIC), or where significant savings in data volume warrants, in 16-bit binary integers. Floating point formulas should be avoided because of the variety of formats in use on different computer systems and the potential for significant errors, difficulty in interpretation, and the inherent higher precision afforded by scaled integers. While the wide variety of multibeam echo sounding systems precludes a practicable, single, fixed-field format structure, the initial metadata should fully document the byte order of multibyte integer fields, format or formats used, their contents, and any conditional flags or values by which specific formats are used or selected. The following fields are the essential components of multibeam bathymetric data. (Note that the precision to which fields are specified reflects the current assessment of precision either useful or attainable in the foreseeable future.)

4.4.3 Date/Time: should be expressed in UT and include the century and year (CCYY), month (MM), day of the month (DD), hours (HH), and either minutes to ten-thousandths (MM.MMMM) or minutes with seconds to hundredths (MMSS.SS). Alternatively, Day of the Year (DDD) (Julian day, which is the number of days since the beginning of the year) may be used in place of the month and day of the month. (n.b. the year 2000, being a divisible by 400, is a leap year)

4.4.4 Geographic Position: should be expressed as a latitude and longitude in either:

i) degrees to millionths, i.e., +/-DD.DDDDDD and +/-DDD.DDDDDD

or

ii) degrees and minutes to hundred-thousandths, i.e.,
+/-DD +/-MM.MMMMM and +/-DDD +/-MM.MMMMM

The fields should be signed according to the convention North and East positive. For option ii), minutes and degrees should be treated as additive, i.e., both should be signed (to avoid ambiguity within one degree of the equator or the prime meridian).

Clear documentation of the datum to which the positions are referenced, e.g., WGS84, is essential metadata to geographic position. If tide is applied, the tidal datum must also be given.

4.4.4.1 Position quality may be expressed in one of several forms:

i) A flag to indicate source instrumentation for position, e.g., G-GPS fix position, T-Transit (Doppler) satellite fix, I-interpolated position from fixes, D-smoothed Dead Reckoned position, etc.

ii) An estimated error ellipse, expressed in terms of its semi-major and semi-minor axes and major axis azimuth and representing a specified confidence level.

iii) A value of Positional Dilution of Precision (PDOP) derived from GPS satellite observation geometry. (Note: DOP is an element of quality in that it indicates proper geometry; however, DOP does not assure attainment of a particular positional accuracy).

iv) Other system-dependent characterizations of quality of positional accuracy.

4.4.4.2 Positional offset between navigational instrumentation and bathymetric transducer system (layback) should be documented.

4.4.4.3 Whatever form of quality indicator is used, its codes, range of values, mode of derivation, and implicit meanings should be fully documented in accompanying metadata.

4.4.5 Bathymetric Depth

There are two broad conventions for reducing multibeam bathymetry, based on either:

i) A standard, nominal mean sound velocity in water (1500 metres/second) or

ii) The measured profile of sound speed through the water column, either measured *in situ* or derived from atlases of previously collected oceanographic data.

It is essential to explicitly document in the metadata which of these conventions apply, the sound velocity structure assumed, and the units used. It is strongly recommended that positional offset information and one, or a combination of the following standard fields should be used to reduce multibeam bathymetric data.

4.4.5.1 Positional offset of sounding positions from that of the survey vessel including:

i) Attitude of the vessel at the time of ping transmission,

ii) Across track offsets, from port to starboard (negative to positive) in metres to tenths (mmm.m), and, if applicable,

iii) Along track offsets, aft to forward (negative to positive) in metres to tenths (mmm.m).

iv) Layback (as noted in 4.4.3.2 above).

4.4.5.2 Corrected depths, paired with and corresponding to, the positional offsets, expressed in metres to tenths (mmm,m), with a clearly documented source of the keel sound velocity and sound velocity profile on which the depth was based.

4.4.5.3 Uncorrected depths (based on an assumed, mean sound speed), paired with and corresponding to, the positional offsets, expressed in metres to tenths (mmm.m), with clear reference to the assumed mean sound velocity, the keel sound velocity, and the sound velocity profile on which the positional geometry of the sounding was based.

4.4.5.4 An array of two-way travel times for the individual beams, in milliseconds, combined with ship attitude data (roll and pitch), to a tenth of a degree. While this form is very near to the primary data, derivation of the bathymetry requires considerable calculation involving ship and system geometry, sound velocity profile, and refraction of the raypaths to the bottom. Thus, this is a secondary standard, to be used in supplement of the forms above.

4.4.5.5 It is essential that the data are accompanied by clear and unambiguous documentation of the standard(s) used, of corrections that have been applied, and of the sound speed profile employed in the echo sounder. It is strongly recommended that the depth be corrected for the transducer depth and, if possible, in shallow water (depths less than 200 metres), for the state of the tide.

4.4.5.6 A conventional null value should be entered in the appropriate depth fields if a valid depth value is missing, e.g., an outer beam suffers signal-to-noise degradation below a critical threshold. It is recommended that zero be the standardized null value for the depth fields; whatever null value is adopted should be used consistently throughout the data structure and should be clearly documented.

4.4.5.7 A bathymetry quality parameter should be included in the data structure. This may be as simple as a character flag for suspect values or as detailed as the signal-to-noise ratio for each beam and sounding. Whatever form of quality indicator is used, its codes, range of values, mode of derivation, and implicit and explicit meanings should be fully documented in accompanying metadata.

4.4.6 Sound Velocity Profile (SVP) measurement of the water column is an essential component of multibeam bathymetric systems as all raypaths, save the vertical beam, are subject to refraction from straight lines. All systems require an input profile for initial processing of the data and some systems use vertical beam bathymetry along track as source data for inversion to derive a sound speed profile. Should the data be provided in beam and travel time form, the SVP is essential to producing a usable array of depths and offsets. The resulting importance of the SVP data means that the functional SVP at any time should be stored with depth data, in a clearly documented and explained form. These particular metadata should be considered an integral part of the primary depth data.

4.4.7 Side-Scan Imagery Data (Optional) is readily derived from many multibeam bathymetric systems. Thus, a multibeam data structure should include provisions for either primary data from which a side-scan image of acoustic backscattering strengths might be constructed, or a side-scan image composed of positioned pixels of specified amplitude, or both.

4.4.8 Other geophysical data and instrumentation observations would not be efficiently stored within a data structure for multibeam bathymetry, given the orders of magnitude greater volume of multibeam data. However, it is highly advisable to extract vertical beam data, subsample them at one minute intervals, and treat the result as a high-quality single beam bathymetric data stream (see Part 3). In this way, the volumes of bathymetry, magnetics, and gravity are more equitable, producing a structure from which retrieval of any of the data types is reasonably efficient. Furthermore, the subsampled vertical beam data serves the dual purposes of:

1) an index to the spatial distribution of the multibeam data, and

2) an access to the data for those without the resources or sophistication to deal with the full-resolution multibeam data set.

4.5 - DATA DOCUMENTATION

It is essential, when data are exchanged, that clear documentation, metadata, is provided defining precisely:

a) The format in which the data are stored, and

b) The conditions under which the data were collected and processed.

The data documentation should preferably be stored in a computer compatible form together with the data. This is especially true of multibeam bathymetry where some of this data documentation is intimately linked in the interpretation of the primary data.

There are five components to the documentation, viz.:

1) Detail about the cruise, platform.

2) Details about the data structures and format in which the data are presented.

3) Information about the navigational systems and data.

4) Information about the bathymetric systems and data.

5) Information about the environmental parameters, especially those that directly affect the data, such as the sound-velocity profile, surface water sound speed, and weather and sea state.

ANNEX A

NOMENCLATURE FOR VARIOUS ASPECTS OF BATHYMETRIC DATA

1. Accuracy, precision, and resolution: Resolution can best be related to the root word, resolve, i.e., to separate. Resolution is the scale length at which two objects just appear to be separate entities. At physical separations smaller that the resolution, they appear as a single object, at physical separations greater than the resolution they clearly appear as two objects. The units of resolution are those of length. Accuracy and precision are a bit more problematic, because in common English usage, they are somewhat synonymous. Accuracy, in the context of measurement means the degree of conformity to some recognized standard value or value accepted as true. In comparison, precision is defined as the degree of refinement with which an operation is performed or a measurement stated. Precision is also a measure of reproducibility, to be further refined as *absolute precision*, stated in the same units as the measurement or result and *relative precision*, which expresses the uncertainty in terms of a fraction of the value of the result. The number of significant digits, or bytes, used to express a value, are then measures of relative precision, while the units in which the data are stored determine their absolute precision. The care with which measurements are made, the thoroughness with which metadata are recorded and properly applied, and the fullness of understanding the measurement, will ultimitely determine the accuracy of any measurement.

2. Cruise and survey: A cruise is usually considered a temporally contiguous, port-to-port operation, with data usually recorded as a function of increasing time. A survey is generally considered a spatially contiguous collection of data, within a bounded geographic area and not necessarily accumulated during a single time interval. There is again some overlap in the English usage of these terms.

3. Course and heading: Course is the horizontal direction in which a ship is steered or intended to be steered, while heading is the instantaneous horizontal direction in which a ship is pointed. Prime distinctions between the two terms are the time scale and the intent. Further refinements of course include frame of reference, such as true, magnetic or grid; the prospective or retrospective time frame, such as course made good (CMG), course of advance (COA) or course over ground (COG). Heading, as a component of the instantaneous attitude of the ship, is constantly changing, and is highly pertinent to multibeam geometry.

ANNEX B

SUPPORTING DOCUMENTATION FOR MULTIBEAM ECHO SOUNDING DATA

An essential part of any digital data series is the documentation describing how the data were collected and processed, the instrumentation used, the methods used for correcting the data, the originator's assessment of the quality of the data, the logging of instrument malfunctions, etc. For multibeam echo sounding, the recording of such metadata is particularly important due to the complexity of the system. Such metadata normally would be recorded in digital form, but might also be in hard copy form. Below is a listing of such data, but depending on the type of multibeam system in use, there may be need for recording of additional data, i.e., the listing is not necessarily comprehensive.

NAME AND TYPE, INCLUDING MODEL, OF MULTIBEAM ECHO SOUNDER: ...

.....
(Serial numbers for component parts of a system, which may impact the observations, can be usefully recorded and may be noted under additional comments when equipment is changed)

TOTAL WIDTH OF ARRAY: .....

USABLE WIDTH OF ARRAY: .....

(under certain conditions the total array may not meet the desired accuracy standard causing certain beams to be eliminated from use)

INDIVIDUAL BEAM WIDTHS: .....
(it is recognized that some systems have variable beam widths and these should be recorded)

FREQUENCY OF THE SOUNDING SIGNAL (kHz): .....

(if variable frequencies are used, each frequency must be recorded along with its time of use)

INSTRUMENTAL SAMPLING RATE (soundings/second): .....
(the ping rate, which may be variable depending on depth, must be included in the record)

DATA RECORDING:

Time resolution (navigation):	Hundredths of a second (.01 s) or Ten-thousandths of a minute (0.0001 mn)
Time resolution (sounding-two way travel times):	Milliseconds (0.000001 ms)
Date:	Century and year (CCYY), month (MM) and day of the month (DD) or Century and year (CCYY), Julian day (DDD)

Depth resolution:	Tenths of a metre (0.1 m)
Depth null value:	"Zero" is recommended, see paragraph 4.4.5.6
Horizontal resolution:	Tenths of a metre (0.1 m)
Speed:	Hundredths of a knot (.01 kn)
Heading:	Tenths of a degree (0.1°)
Roll and pitch:	Tenths of a degree (0.1°)
Geographic position:	Degrees to millionths (+/-DD.DDDDDD and +/-DDD.DDDDDD) or Degrees and minutes to hundred-thousandths (+/-DD +/-MM.MMMMM and +/-DDD +/-MM.MMMMM)

OFFSET DISTANCES: .....
(offsets between navigational instrumentation and the bathymetric transducer system must be documented)

SOURCES OF NAVIGATION INFORMATION: .....
(G=GPS, T=Transit, I=Interpolated, D=Dead reckoned, etc.)

CROSS-TRACK OFFSET CONVENTION: .....
(the cross-track offset convention used, port to starboard (negative to positive) recorded in tenths of metres)

DATUMS: .....
(indicate horizontal datum and, where tides are applicable, vertical datum, including information to clearly indicate the source of tidal correctors applied, i.e., actual or predicted tides and the stations used)

TRANSDUCER DEPTH CORRECTION: .....
(indicate any transducer depth correctors applied and note that for towed transducers this depth may vary with ship speed and should be continuously monitored)

NOMINAL SOUND VELOCITY: .....
(state nominal mean sound velocity in water, e.g., 1500 metres/second)

SOUND VELOCITY CORRECTIONS: .....
(state clearly the methods used for sound velocity correction and the method used to obtain correctors, e.g., a) *in situ* measurements at the time of survey, b) Third Edition NP139 of the Hydrographic Department of the UK, c) Second Edition NP139-Matthews Tables, or d) other, please specify) (For systems where beamforming is used to maintain a vertical transmit beam, indicate the sound velocity of the water at the keel)

DATA REDUCTION SOFTWARE: .....
(indicate the type and version of any software used for data acquisition and reduction, including use of filtering of detected errors, and any quality enhancement procedures used such as along-track averaging) (Also, cross referencing and adjustments to navigation information must be fully

documented)

DATA STRUCTURES AND FORMAT: .....
(details about the data structure and format in which data are presented must be documented)

ENVIRONMENTAL DATA: .....
(since multibeam data quality is particularly sensitive to environmental conditions, parameters such as the sound-velocity profile, surface water sound speed (ksv), weather and sea state must be given)

ADDITIONAL COMMENTS: .....

.....

.....
(Complete documentation to describe how the data were collected and processed is essential and the record must indicate any malfunctions to hardware or software or other errors that have a bearing on the quality of the data) (note that a data quality parameter should be included in the data structure and the form used, i.e., codes, should be fully documented)

Note: The original draft from the Sub-Committee proposes that "Roll and pitch" and "heading" be recorded to 0.1 degree but the I.H. Bureau questions whether ot not these should be recorded to 0.01 degree. Opinions are sought on this issue.

PART 5

UNDERWAY GEOPHYSICS DATA

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CONTENTS

5.1 - INTRODUCTION

This chapter contains guidelines for storing and documenting underway magnetic and gravity data collected concurrently with single beam echo-sounding data. It should be read in conjunction with Part 3.

5.2 - STORAGE OF MAGNETIC DATA WITHIN TIME SERIES RECORDS

It is recommended that magnetic field data be expressed in terms of the following items:

5.2.1 **Total Magnetic Field:** expressed in nanoteslas to tenths (FFFFF.F)

5.2.2 **Residual Magnetic Field (Optional):** expressed in nanoteslas to tenths (+/-RRRR.R); sometimes referred to as magnetic anomaly

Residual field = Total field - Reference Field

The reference field used should be clearly identified in the accompanying documentation.

5.2.3 **Magnetic Field Correction (Optional):** expressed in nanoteslas to tenths (+/-CCC.C) and containing the correction applied to the total magnetic field to compensate for diurnal, storm or other effects as described in the data documentation. If used, total and residual fields are assumed to have been already corrected. If set to a predefined null value (e.g. -999.9) then total and residual fields are assumed to be uncorrected.

5.2.4 **Magnetic Field Quality:** a one character flag indicating whether or not the magnetic field value is considered suspect by the originator (e.g. blank = unspecified; "A" = acceptable; "S" = suspect).

5.2.5 It is important that the total magnetic field value should always be stored rather than be replaced by the residual magnetic field. This is to ensure that the residual field can be easily redefined should an improved reference field become available after the original processing of the data, or should a subsequent user of the data wish to standardise on another reference field.

5.3 - STORAGE OF GRAVITY DATA WITHIN TIME SERIES RECORDS

It is recommended that gravity data be expressed in terms of the following items:

5.3.1 **Observed Gravity:** expressed in milligals to tenths (GGGGGG.G) and corrected for Eotvos, drift, bias and tares. The reference system (datum) should be clearly stated in the accompanying documentation, together with information on the base station and the method of tying the data into the system.

5.3.2 **Free-air Gravity Anomaly:** expressed in milligals to tenths (+/-FFF.F)

Free-air anomaly = Observed Gravity - Theoretical Gravity

The theoretical gravity formula used should be clearly identified in the accompanying documentation.

5.3.3 **Eotvos Correction Applied to the Observed Gravity (Optional):** expressed in milligals to tenths (+/-EEE.E)

5.3.4 **Gravity Quality:** a one character flag indicating whether or not the observed gravity value is considered suspect by the originator (e.g. blank = unspecified; "A" = acceptable; "S" = suspect).

5.3.5 **Information note :** Theoretical Gravity Formulae

Heiskanen 1924 : $\tilde{a}_o = 978.052 (1 + 0.005\,285 \sin^2\ddot{o} - 0.000\,0070 \sin^2 2\ddot{o} + 0.000\,027 \cos^2\ddot{o} \cos^2 (\ddot{e} - 18^\circ))$

International 1930 : $\tilde{a}_o = 978.0490 (1 + 0.005\,2884 \sin^2\ddot{o} - 0.000\,0059 \sin^2 2\ddot{o})$

IAG System 1967 : $\tilde{a}_o = 978.03185 (1 + 0.005\,278895 \sin^2\ddot{o} + 0.000\,023462 \sin^4\ddot{o})$

IUGG (1980)
Somigliani : $\tilde{a}_o = 978.0327 (1 + 0.0053024 \sin^2\ddot{o} - 0.000\,0058 \sin^2 2\ddot{o})$

5.4 - DATA DOCUMENTATION

When the time series file also includes magnetic and/or gravity data then additional data documentation should be provided along the lines indicated on the following forms.

SUPPORTING DOCUMENTATION FOR UNDERWAY MAGNETIC DATA

NAME AND TYPE OF MAGNETOMETER : . . . . . .
(including make and model)

INSTRUMENTAL SAMPLING INTERVAL (seconds) : . . . . . .

DIGITIZATION CRITERIA : indicate the criteria and method used for extracting field values from the original instrumental record e.g. peaks and troughs, changes of slope, fixed time intervals (specify the interval), or combinations of the foregoing etc.

. . . . . .

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MAGNETIC SENSOR TOW DISTANCE : . . . . . .

MAGNETIC SENSOR DEPTH : . . . . . .

DESCRIPTION OF CORRECTIONS APPLIED : indicate whether, and if so how, corrections were made for diurnal variations, magnetic storms, effect of the ship's field, or other effects.

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REFERENCE FIELD IDENTIFICATION : identify the Reference Field used in computing magnetic anomaly by a recognised term such as DGRF 1975, PGRF 1975, IGRF 1980 etc. - local or other fields should be clearly described.

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ADDITIONAL COMMENTS (e.g. originator's assessment of data quality and report on any malfunctions or errors):

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. . . . . .

. . . . . .

. . . . . .

SUPPORTING DOCUMENTATION FOR UNDERWAY GRAVITY DATA

NAME AND TYPE OF GRAVIMETER : . . . . . .
(including make and model)

INSTRUMENTAL SAMPLING RATE : . . . . . .

DIGITIZATION CRITERIA (including digitization rate):

. . . . . .

. . . . . .

GRAVITY BASE STATION (DEPARTURE) : description of Station (including name, location and reference no.).

. . . . . .

. . . . . .

Sea level gravity at station (milligals) : . . . . . .
(network value preferred)

GRAVITY BASE STATION (ARRIVAL) : description of Station (including name, location and reference no.).

. . . . . .

. . . . . .

Sea level gravity at station (milligals) : . . . . . .
(network value preferred)

GRAVITY REFERENCE SYSTEM : e.g. Potsdam system, System IGN71 - local or other systems should be clearly described.

. . . . . .

THEORETICAL GRAVITY FORMULA USED : e.g. Heiskanen 1924, International 1930, IAG System 1967, IUGG (1980) Somigliani - if other then specify fully.

. . . . . .

SOURCE OF VELOCITY FOR EOTVOS CORRECTION : Indicate method used e.g. a) Differentiated navigation track; b) Direct measurement from satellite doppler; c) Other (please specify and/or provide an estimate of accuracy of velocity used for Eotvos).

. . . . . .

DESCRIPTION OF CORRECTIONS APPLIED : describe a) method of tying data to Reference System (Datum) and b) corrections applied for drift, tare and bias. Include an estimate of errors and value of corrections applied, and assessment of data quality and a report on any equipment malfunctions.

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